TECHNICAL MEMORANDUM
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DEVELOPMENT OF PROVISIONAL FLIGHT INSPECTION CONCEPTS FOR LOCAL AREA AUGMENTATION SYSTEM (LAAS) APPROACH PROCEDURES

The Local Area Augmentation System (LAAS) is capable of supporting precision and non-precision approach procedures. In addition, it is capable of providing airport surface guidance. In order to implement the LAAS within the National Airspace System (NAS), flight inspection criteria for LAAS must be developed. The five assessment activities to be addressed in this report include: waypoint accuracy, flyability of approach procedures, presence of RF interference, obstruction environment, and VHF data broadcast coverage. This report presents preliminary flight inspection concepts for accomplishing these assessment activities.

by

Soo Y. Braasch, M.S.E.E.
Michael F. DiBenedetto, Ph.D.

Avionics Engineering Center
School of Electrical Engineering and Computer Science
Ohio University
Athens, Ohio 45701-2979

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Washington DC, 20591

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I. INTRODUCTION

Technical Task 2.0 to FAA Contract DTFA01-97-C-00078, titled “Flight Inspection Criteria for Satellite-Based Navigation Systems”, supports the development and verification of flight inspection criteria for satellite-based navigation systems. These criteria are intended to provide a suitable means for implementation and integration of satellite-based navigation systems into the National Airspace System (NAS).

In order to facilitate the integration of satellite-based navigation systems into the NAS, standards must be developed based on specific operational requirements and system architectures. The objective of these standards is to detail, in terms of system-architecture-specific parameters, the minimum performance required to support a given procedure. The standards development process includes the generation of flight inspection criteria. These criteria address the specific system parameters to be assessed and the assessment methodology required to ensure that the installed-system performance is suitable for supporting the intended procedure(s). Such flight inspection criteria must be developed and verified to enable the implementation of the Local Area Augmentation System (LAAS).

The following specific work items are intended to be performed under this technical task directive:

Parameter Identification - Develop a list of specific system parameters that will be recorded during flight inspection of LAAS procedures.

Assessment Methodology - Develop methodologies for assessing the data collected for the system parameters identified.

Criteria Development - Provide technical support for the development of LAAS flight inspection material for inclusion in the appropriate FAA Orders.

Verification - Through the use of FAA and Ohio University facilities and resources, verify the flight inspection criteria that have been developed. Through actual implementation, assess the technical merit of the specific parameters considered, data collection and assessment methodologies utilized, and any implementation issues that may arise during the actual application of the criteria.

This report describes the LAAS Precision Approach (PA) procedure and its components. A preliminary description of the parameters that must be recorded and the assessment methodology needed during flight inspection for Category I precision approach operations are described. Due to schedule constraints, this preliminary report does not provide an in-depth analysis of the criteria development. At the present time, this report provides insight into the LAAS flight inspection procedure from an analytical viewpoint, i.e., the development of Flight Inspection concepts. Once these are validated, the development of the more specific flight inspection criteria will be based on these concepts. There were no attempts to verify the concepts via actual implementation of a LAAS airborne system; however, the Avionics Engineering Center strongly recommends that verification of the LAAS Flight Inspection concepts be performed.

II. OVERVIEW OF GPS/LAAS PROCEDURES AND FLIGHT-INSPECTION REQUIREMENTS

The development of the LAAS Flight Inspection concepts is based on the site-specific components of a LAAS instrument approach procedure. While both the space and ground components of the GPS affect the LAAS approach, the flight inspection procedure relies on the inherent monitoring inherent within these components to determine faults. The same philosophy applies to the LAAS/GPS receiver. The flight inspection procedure is not intended to provide an assessment of receiver performance as this matter is appraised during equipment certification. This philosophy does not exclude the recording of GPS and LAAS parameters, however. These parameters are needed to determine why an inspection run may have failed and for determining if there has been any local corruption or interference of the signal.

A. Overview of GPS/LAAS Procedures

1. **Basic "T"**

As illustrated in Figures 1 and 2, the GPS approach procedure uses the Basic "T" with the addition of a terminal arrival area (TAA). The Basic "T" is used for stand-alone GPS approaches (TSO C-129), as well as LAAS and WAAS approaches.

The Basic "T" aligns the final approach segment with the runway centerline. The Missed Approach Point (MAP) is at the runway threshold and the Final Approach Fix (FAF) is 5 nmi from the threshold. The Intermediate Fix (IF) is 5 nmi beyond the FAF, along the runway centerline. There are two Initial Approach Fixes (IAF) located 4 or 5 nmi either side of the IF. The IAFs are typically located 90 degrees with respect to the runway centerline. The GPS procedure is designed to eliminate the procedure turn. If a course reversal is required, a holding pattern will be specified in lieu of a procedure turn.

The TAA (shown in Figure 2) provides the transition from enroute airspace to the GPS approach. Step-down altitudes and transitions are provided for all approach paths except for areas where terrain clearance or ATC limitations are required. The TAA is typically defined for a 30-nmi arc from the IAF. There are three areas in the TAA. Aircraft transitioning to the Basic "T" from a heading that is within 90 degrees of the final approach course are directed to the IAF/IF. The IAF/IF is located at the IF on the extended runway centerline. Aircraft that are approaching the GPS procedure with a bearing greater than 90 degrees to the final approach course are directed to one of the IAFs. These aircraft are approaching the GPS procedure from the left or right base.

To accommodate FMS and RNAV approach equipment, waypoints are designated as Fly-Over or Fly-By. Fly-By waypoints are used when the navigation system is allowed to transition from one segment to the next segment before passing the waypoint. This technique provides what is known as turn anticipation. Terrain and obstacle clearance must compensate for turn anticipation.

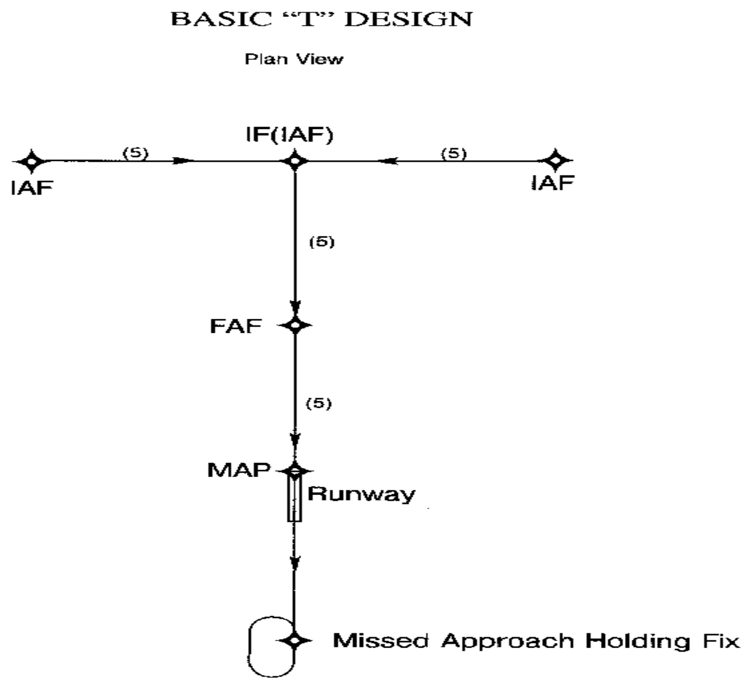

Figure 1. Basic "T" GPS Approach Procedure [1]

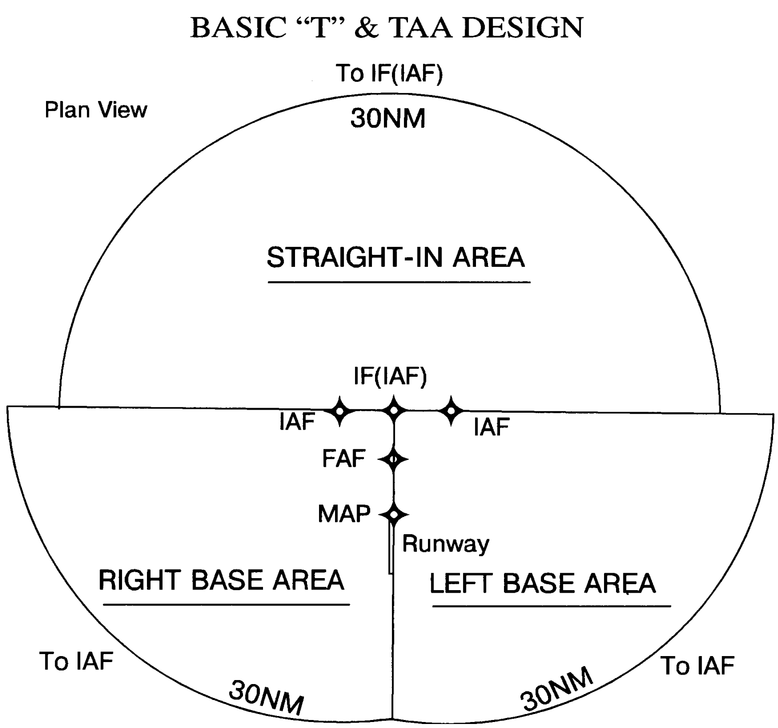

Figure 2. Terminal Arrival Area for GPS Approaches [1]

2. **Non Precision Approach (NPA)**

Both ground and airborne LAAS equipment specifications provide support for non-precision approaches. In the LAAS Final Approach Segment (FAS) data uplink, message Type 4 provides status on vertical /lateral alert limits (VAL/LAL). A coding of all ones in the vertical indicates that vertical guidance is not available. A coding of all ones in the lateral indicates that the approach is not available [6].

On the airborne side, vertical deviation outputs are invalidated if the Message Type 4 FAS VAL/Approach Status indication is coded as all ones or the vertical protection level exceeds the vertical alert limit. However, both lateral and vertical deviation outputs are invalidated if the Message Type 4 FAS LAL/Approach Status indication is coded as all ones or the lateral protection level exceeds the lateral alert limit [7].

As a result, the LAAS can provide lateral guidance even when vertical guidance is unavailable. The LAAS thus supports non-precision approaches. In practice, a LAAS NPA may be used in two situations. First, the pilot may select an NPA; second, system accuracy, availability, or integrity may inhibit a PA which causes the system to revert to an NPA.

A GPS NPA consists of sequenced waypoints from the initial approach waypoint (IAWP) to the Missed Approach Waypoint (MAWP). After the aircraft passes the FAWP, it is allowed to descend to the Minimum Descent Altitude (MDA). There is no vertical guidance for an NPA. During the commissioning Flight Inspection, all the Initial Approach Segments (IAS) and Missed Approach Segment (MAS) are flown at the procedural altitudes. An IAS may be evaluated when flying by the IAWP if it is a Fly-By waypoint for turn anticipation. The Final Approach Segment (FAS) is verified to be a straight line from the FAWP to the MAWP. The flight inspection procedure starts three nmi outside the first waypoint in a straight line with the FAWP and MAWP. This may be either an IWP or the FAWP. All the waypoints that are on this procedure are evaluated by flying over the waypoints. The FAS is flown to 100 feet below the published altitude (MDA) from the FAWP to the MAWP. Only the FAS is checked during periodic flight checks [2].

3. **Precision Approach (PA)**

The LAAS PA can be established via the Basic “T” Approach configuration presented in Figure 1 or via the Vector To Final (VTF) procedure. In the Basic “T”, the Initial/Intermediate Approach Segments are similar for the LAAS and non-precision approach procedures. In the VTF procedure, the aircraft discontinues the initial/intermediate segments on the published approach and is vectored to an extended final approach segment.

The horizontal and vertical components of the FAS are calculated from waypoints associated with the runway environment as shown in Figure 3. The horizontal course is defined as an extended runway centerline using the Runway Datum Point marked LTP/FTP in Figure 3 (landing threshold point/ficticious threshold point) and the Flight Path Alignment Point (FPAP).

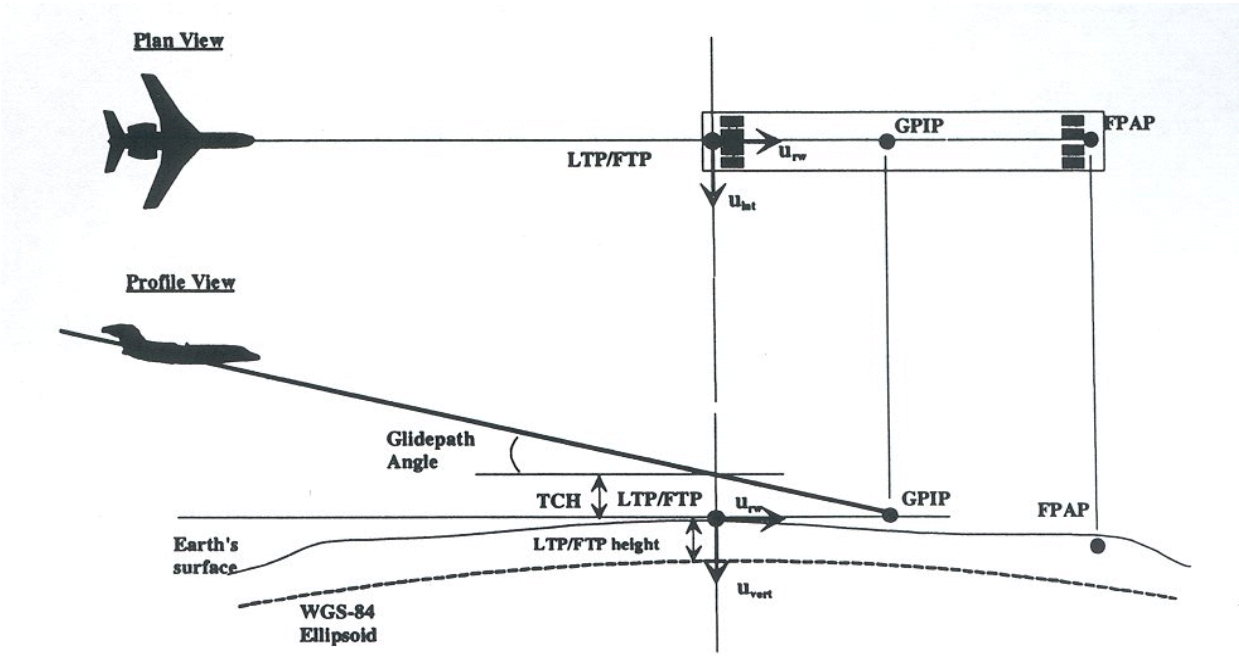

Figure 3. Final Approach Segment of LAAS Precision Approach [6]

A straight-in approach is currently defined for LAAS PA operations although the approach path may be offset from the runway centerline. This is accomplished by moving the LTP/FTP and/or FPAP to a point off the runway surface.

A linear path defined by the Threshold Crossing Height (TCH) and the glidepath angle establish the vertical course. The glidepath angle is defined with respect to the local tangent plane of the WGS-84 ellipsoid. The Glide Path Intercept Point (GPIP) is where the glidepath intersects the local tangent plane. The GPIP is not part of the FAS database, but is only included for reference.

The Type 4 Message shall contain the FAS data for each runway [6], the FAS parameters shall be provided and uplinked by the LAAS ground facility (LGF). The LGF shall broadcast the FAS data every 10 seconds at a minimum. The FAS data includes the following: Runway Datum Point (LTP/FTP), Flight Path Alignment Point, Datum Crossing Height and Glidepath Angle.

B. <u>General Inspection Requirements</u>

LAAS Flight Inspection criteria outline the parameters and their respective tolerances which will define whether an approach is approved or not. Criteria used in this determination are listed below.

1. *Waypoint Displacement Error (WPDE)* – WPDE describes the positional error associated with a waypoint. WPDE can be caused by incorrect geographic coordinates or the resolution in which the coordinates are stored in the database.

4. *Lateral Protection Limits (LPL)/Vertical Protection Limits (VPL)* - LPL and VPL are computed by the LAAS receiver. They denote the uncertainty associated with the 3-dimensional positional accuracy that is output by the receiver. LPL/VPL are affected by the number of GPS satellites, GPS satellite geometry (HDOP/VDOP), and the accuracy of the ground reference station and the LAAS receiver. LPL/VPL are compared to the Lateral Alert Limit/Vertical Alert Limit (LAL/VAL). The LAL and VAL are set to be 40 meters and 10 meters for the Category I operations [4]. If the VPL exceeds the VAL limit, the vertical guidance shall be flagged by the LAAS receiver. If the LPL exceeds the LAL, both the vertical and lateral guidance shall be flagged.

5. Obstruction Clearance - All aircraft paths approved by the approach procedure must be free of obstacles and obstructions. This may include towers, buildings, and terrain. Obstruction clearance is initially determined by examining FAA and other government databases. During the flight inspection, obstacle clearance is determined by pilot observation.

6. *RF Interference* - The electromagnetic spectrum in the GPS L1 band is monitored if RF interference is suspected. The frequencies to be monitored are in the range of 1555 to 1595 MHz. The normal GPS signal strength is -130 to -123 dBm. Particular attention shall be given to harmonics on or within 20 MHz of GPS L1 (1575.42 MHz) [8].

7. *Standard Instrument Approach Procedure (SIAP*) - The instrument approach procedure must be checked for flyability, waypoint accuracy, obstructions, and interference. The entire SIAP is checked from Initial Approach Waypoints to the Missed Approach Holding Waypoint.

8. *VHF Data Broadcast Coverage* - The LAAS VDB shall provide sufficient coverage to support all relevant flight operations within the terminal area. A single LAAS ground facility is expected to provide for precision approach procedures to all runway ends at a given airport. VDB coverage must allow for support of all dependent missed approach and vector-to-final (VTF) procedures including generous allowance for flight technical error(s) (FTE).

In addition to supporting precision approach procedures, the LAAS may be expected to support airport surface operations. These operations may include providing electronic taxi guidance in the cockpit and supporting surface surveillance operations using Automatic Dependent Surveillance Broadcast (ADS-B) with LAAS as the sensor providing differential GPS corrections.

In order to support the aforementioned operations, the VDB coverage volume should be omni-directional and should include the airport surface. The VDB coverage volume specified for

Performance-Type-One Local Area Augmentation System Ground Facility is [3]:

Laterally:

1. encompassing 360^{o} around the VDB antenna,
2. beginning at 200 m from the VDB antenna, and
3. extending to 23 nmi.

Vertically, within the lateral region:

1. within three nmi of the VDB antenna, between the horizontal plane 12 feet above the ground at the antenna and a conical surface inclined at 85^{o} above the horizontal plane, up to the height of 10,000 ft.
2. from three nmi to 23 nmi, between 10,000 feet AGL and a conical surface that is inclined at 0.9^{o} above the horizontal plane with an origin 274 feet below the ground at the antenna.

Figure 4 illustrates the VDB coverage volume described above. The actual lower limits of the coverage will be site dependent and will be influenced by signal blockage by objects or terrain in the vicinity of the VDB transmitter antenna. In addition, the effective VDB antenna pattern is a function of antenna height, polarization, ground plane material and size of the ground plane. These issues will be explored further in the next section.

C. <u>VDB Assessment Issues</u>

As mentioned in the previous section, the VDB coverage volume is designed to support all relevant flight and ground operations within the terminal area. Actual installed performance, however, can vary significantly from the specified coverage volume. Influencing factors include transmit antenna height-above-ground, polarization, ground-plane material, ground-plane size, and blockage by objects in the environment.

Even in the absence of blockage from objects in the environment, a key issue affecting the coverage achieved will be signal nulls or fading induced by ground reflections. To minimize this effect, some VDB antennas are designed with a slight roll-off in the vertical pattern at the horizon. Even in this case, notable fading of the VDB signal within coverage may exist if the antenna is not properly sited and installed. Therefore, flight inspection procedures must be developed that provide for efficient inspection of the achieved coverage.

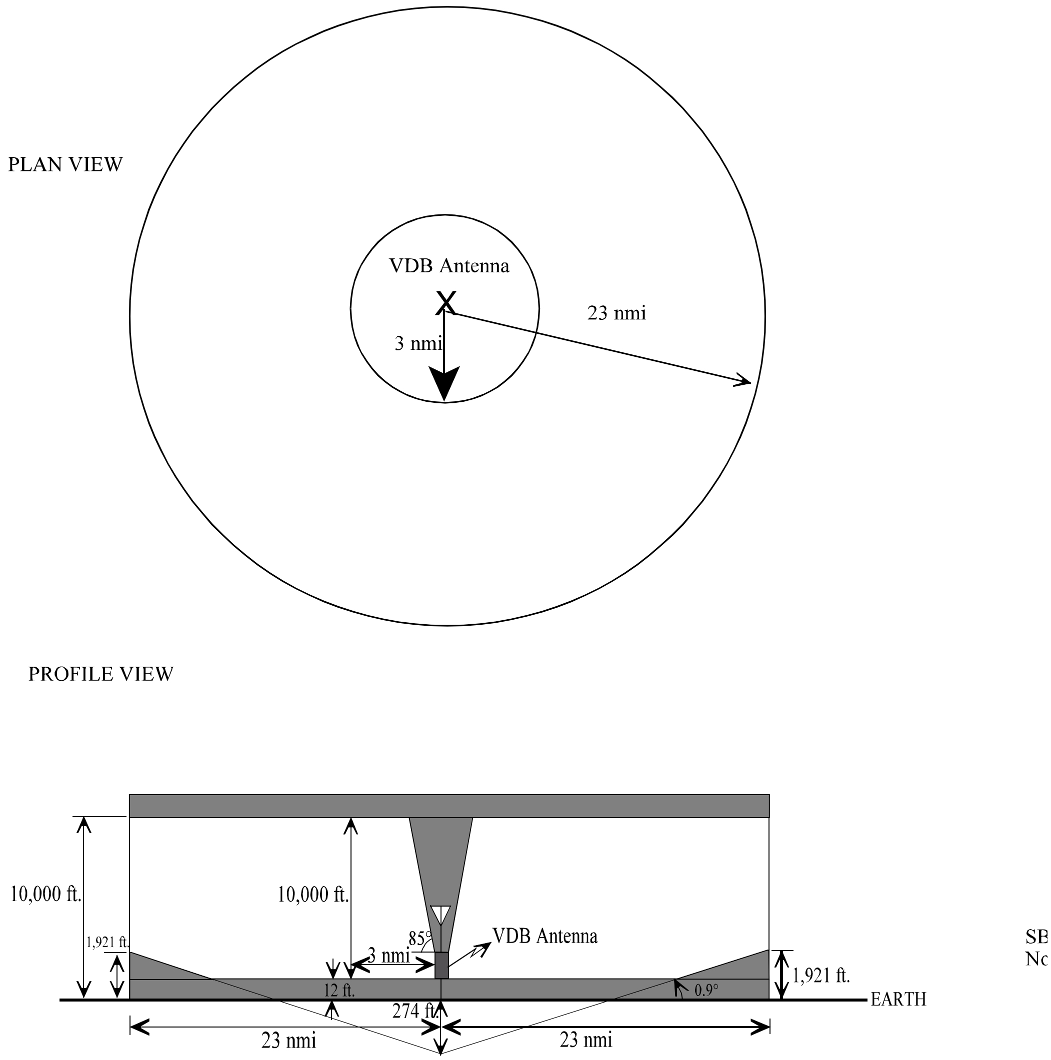

Figure 4. LAAS VDB Coverage Volume

As specified, the VDB must radiate a right-hand elliptically polarized (RH EPOL) signal [3]. However, it is expected that the vast majority of users will have either a horizontally-polarized or a vertically-polarized receive antenna. As a result, it is not essential that the *handedness* and axial ratio of the broadcast signal be checked during flight inspection. These items are checked during equipment acceptance testing. Instead, the flight inspection aircraft should be equipped both with horizontally-polarized and vertically-polarized receive antennas. Separate assessments should be performed for each polarization, as will be substantiated by the information that follows.

1. **Simulation / Analysis**

In order to illustrate the influence of antenna height, polarization, and ground-plane material on the lobing of the antenna pattern, a simulation study was performed. In order to isolate the effects of the aforementioned parameters, a single-point source over an infinite ground plane was simulated. The point source represents the worst-case in terms of antenna design.

The analysis presented here assumes a level-pass maneuver for the observation points. In order to observe the fading pattern, antenna heights of 13, 26, 50 and 100 feet were used in the simulation. In addition, three different ground-plane materials were chosen for the study (perfect conductor, dry soil, and wet soil) along with level-pass altitudes ranging from 2000 to 10,000 feet. Each of the aforementioned factors contributes to the characteristics of the fading pattern as will be explained in the following sections.

2. **Antenna Height**

The effect of transmit antenna height-above-ground is illustrated in Figure 5. For these plots, the level-pass altitude is 2000 feet. The upper envelope reveals the $1/R^2$ relationship between received power and distance. As could be expected, the number of lobes is proportional to the antenna height-above-ground. The lobing associated with high antennas is likely to be operationally unacceptable.

The recommended antenna height varies with the design and assumptions made about the ground-plane material. Currently, antenna heights of 13 to 45 feet are anticipated when the antenna is installed to support precision approach operations. However, there are instances where the selection of the proper antenna height can be more complicated than simply determining the height of the antenna at the installation site. At airports located in hilltop or mountain top areas, sharp drop-offs are not uncommon. If the VDB antenna is sited near the edge of the plateau, the effective height of the antenna could be much greater than the 'installed' height (Figure 6). If such a situation occurs at an actual installation, flight inspection must detect the presence and determine the acceptability of the resulting nulls in the antenna pattern.

The previous received power plots assume a smooth, perfectly-conducting ground plane which is the worst-case condition. Actual ground materials (e.g., wet soil, dry soil) have conductivities in between theoretical insulators and conductors thus yielding lower reflection coefficients depending upon polarization and angle of incidence. The effects of polarization and ground conductivity will be addressed in the next sections. Furthermore, the ground is neither perfectly flat nor perfectly smooth. All of these factors can help to reduce the impact of the ground reflections.

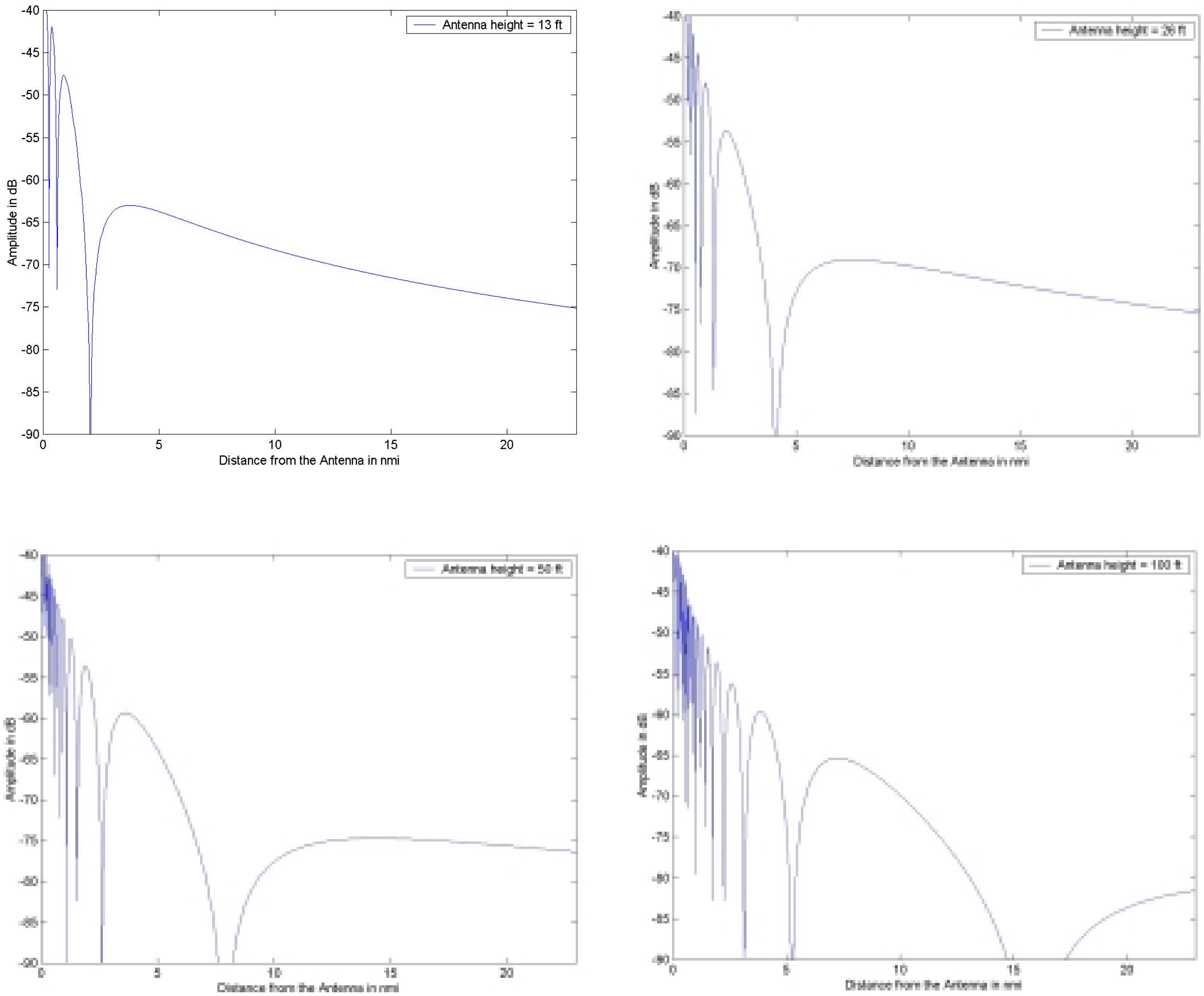

Figure 5. Effects Due to Antenna Height on Vertical Polarization Antenna Pattern with a Perfect Conductor (σ = ∞).

3. **Polarization**

The effect of polarization is illustrated in Figure 7. For the case of a perfectly conducting ground plane, the reflection coefficient for the vertical polarization is +1 while the coefficient for horizontal polarization is -1. As a result, the lobing for the two polarizations are out of phase.

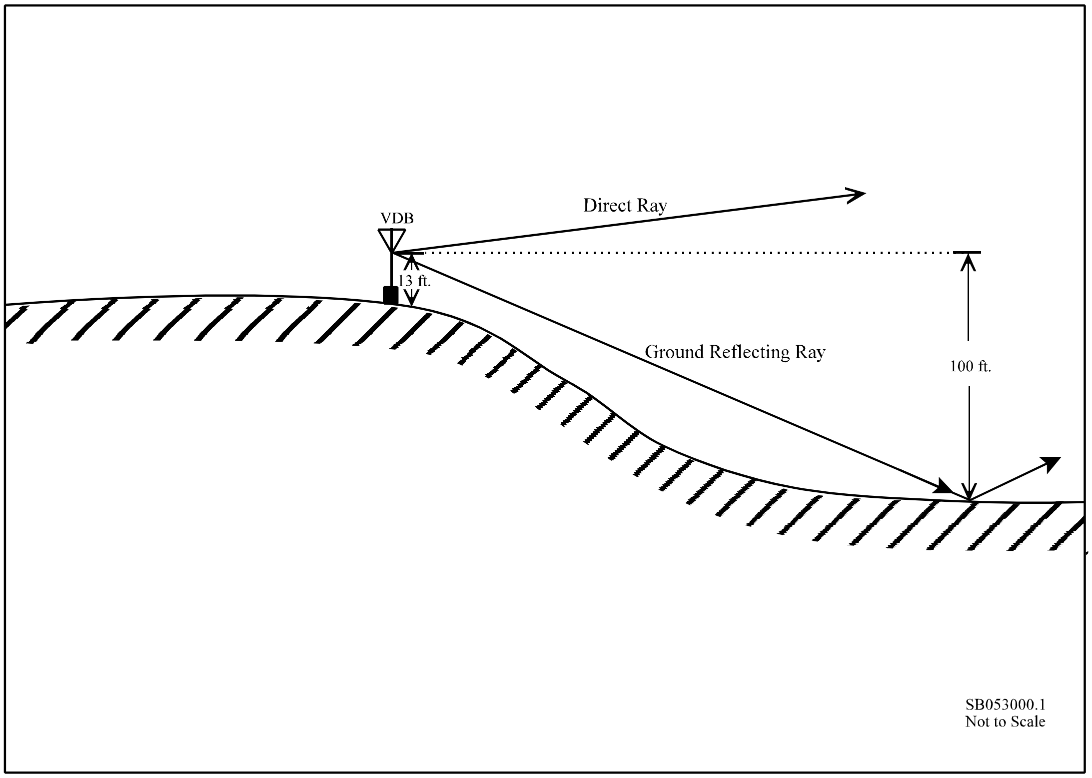

Figure 6. VDB Antenna Sited Near the Edge of the Plateau Hill Top

However, it is shown that the two are in-phase for the case of wet and dry soil. This is due to the fact that the vertical polarization reflection coefficient changes from +1 to -1 for incidence angles greater than the Brewster angle, which is around 67 degrees for this these soil types [9]. As illustrated in Figure 8, for a level-pass altitude of 2000 feet, the angle of incidence exceeds the Brewster angle for all but a small segment. By way of brief review, it should be remembered that angle of incidence is measured with respect to the normal to the reflecting plane. In these simulations, the angle of incidence is approximately the complement of the elevation angle of the observation point. See Appendix A for plots of elevation angle versus level-pass distance.

4. **Ground Plane Material**

The influence of ground plane material may be observed in Figure 9. The horizontal polarization reflection coefficient does not change phase instantaneously as in the vertical polarization case at the Brewster angle. It may also be observed that the differences between the three materials (perfect conductor, wet soil, dry soil) for the horizontal polarization cases are virtually negligible. This is due to the high angle of incidence occurring over most of the plot. As an example, the magnitude and phase of the reflection coefficients for horizontal and vertical polarization incident on dry soil are given in Figure 10. Although the lobing and fading pattern is similar for all three ground planes (horizontal case), the null depths are not equal. In marginal cases, this could cause an installation to be acceptable during dry conditions but unacceptable during extreme wet periods.

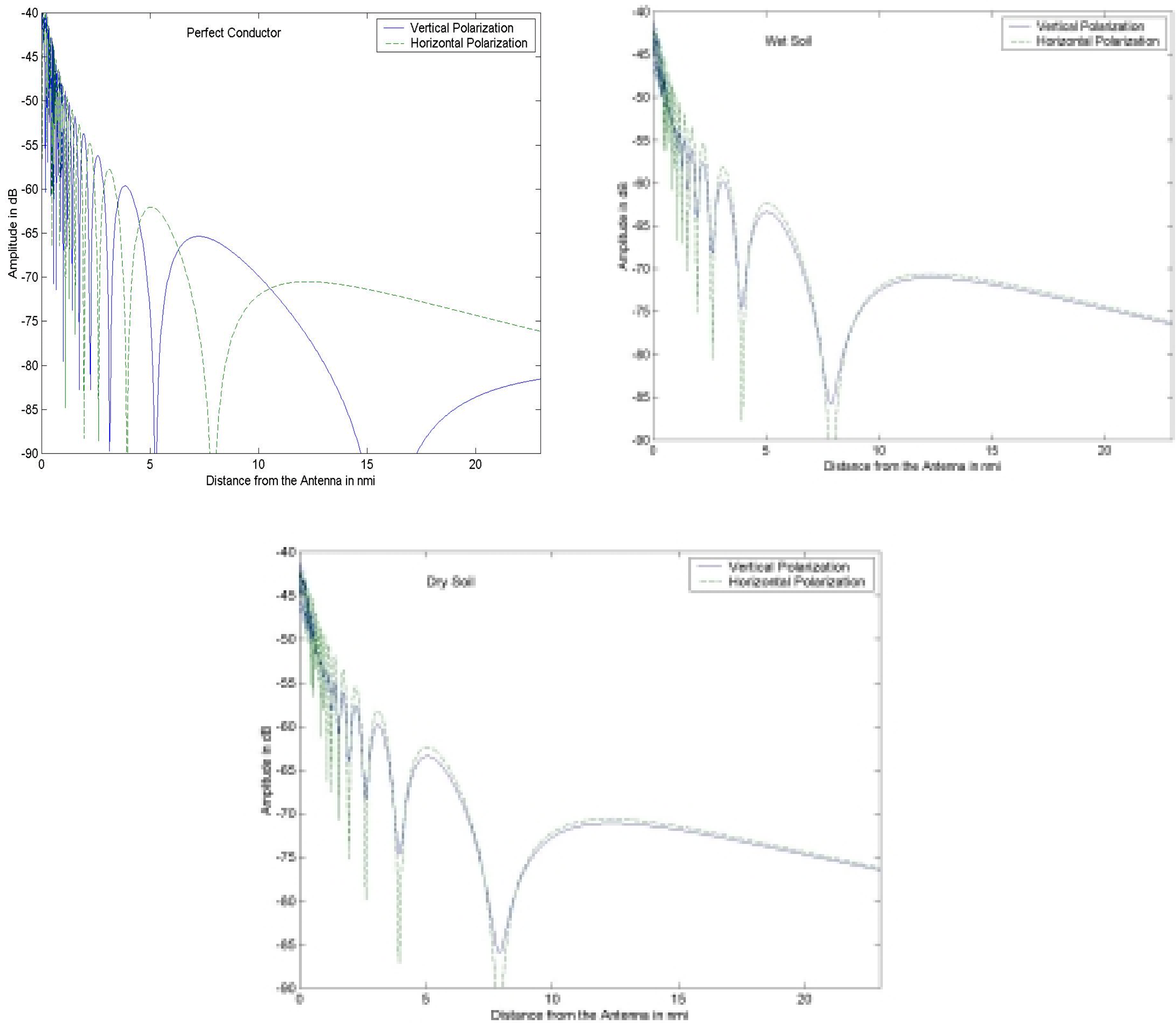

Figure 7. Effects Due to Polarization as Illustrated in these Received Power Plots. VDB transmit antenna is 100 feet above ground. Level-pass altitude is 2000 feet. Three ground materials are considered: Perfect Conductor ($\sigma = \infty$ mhos/meters (s/m)), wet soil ($\sigma = 10^{-2}$ s/m), dry soil ($\sigma = 10^{-4}$ s/m).

At high angles of incidence, the magnitude of the horizontal reflection coefficient is between 0.5 and 1 and the phase angle is nearly constant. However, in the vertical case both the magnitude and phase of the reflection coefficient vary significantly between the perfect conductor and the dry soil case, for example.

5. **Appendix Materials**

The received power plots, as a function of level-pass distance from the VDB antenna in this section, represent a small sample of the plots generated during the analysis. For reference purposes, the complete set of plots is located in Appendix B.

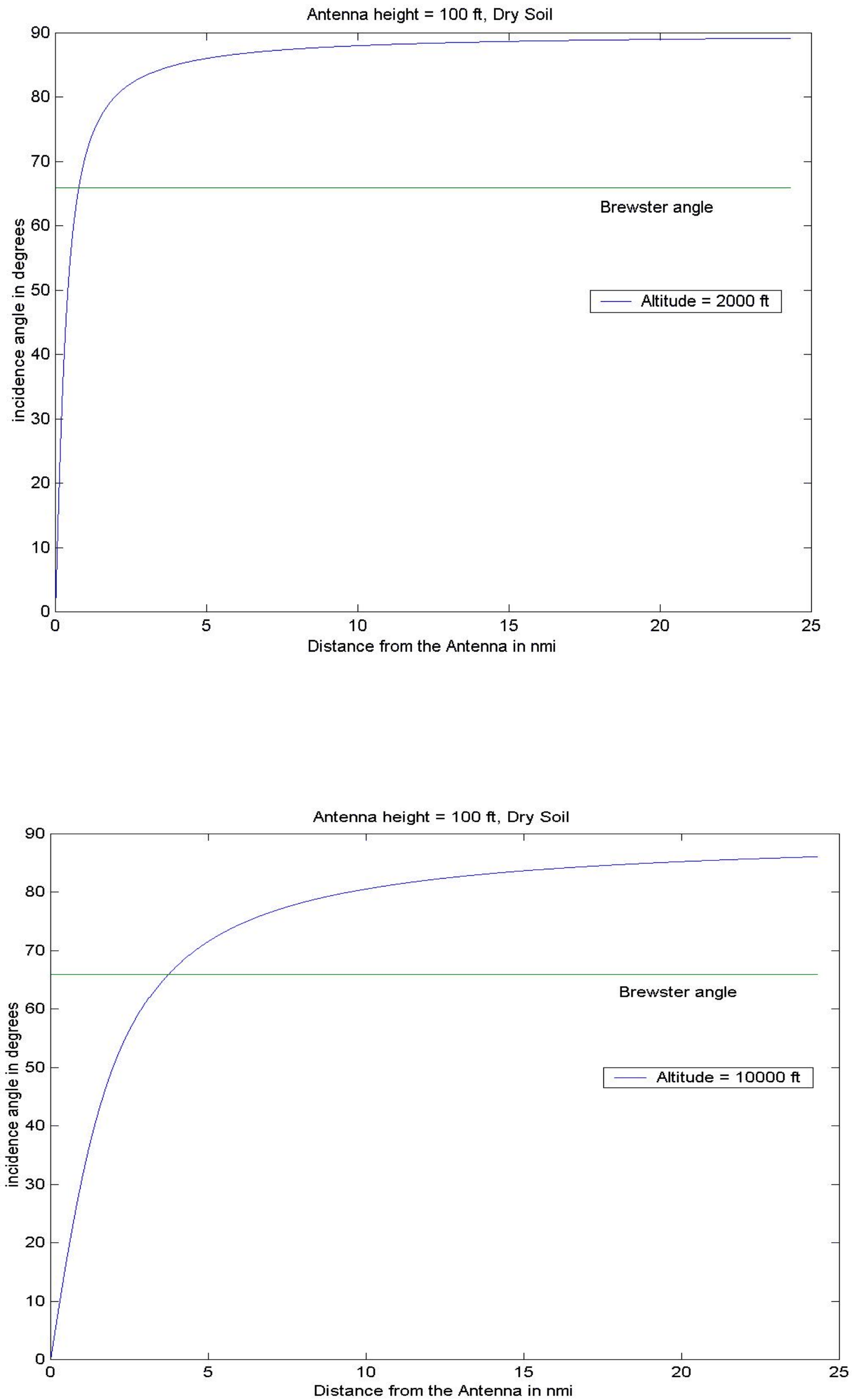

Figure 8. Examples of Brewster Angle with Dry Soil ($\sigma = 10^{-4}$ s/m)

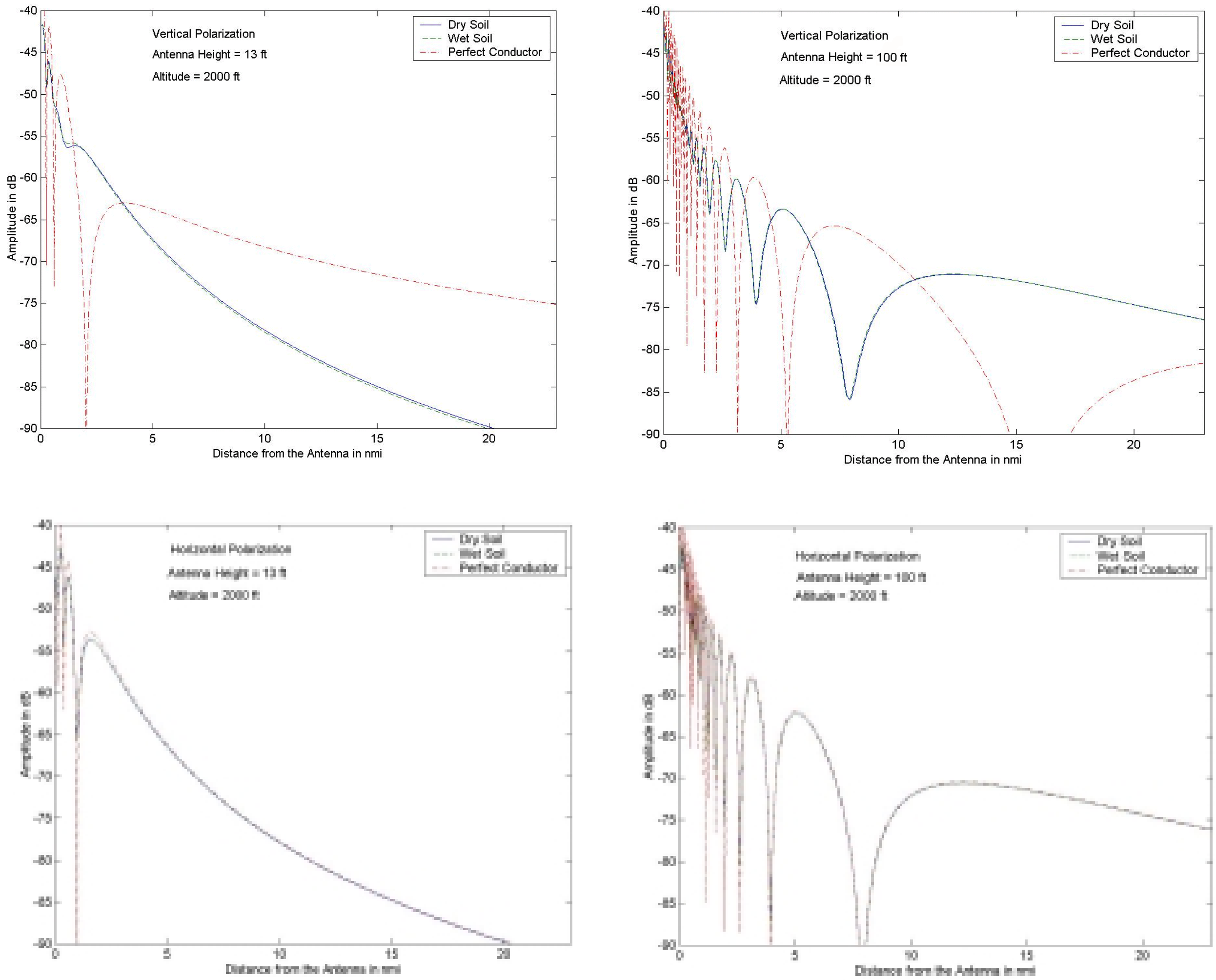

Figure 9. Effects Due to Ground Plane Material as Illustrated in these Received Power Plots. Antenna is 13 feet and 100 feet above ground. Level pass altitude is 2000 feet. Three ground materials are considered: perfect conductor ($\sigma = \infty$), wet soil ($\sigma = 10^{-2}$ s/m), dry soil ($\sigma = 10^{-4}$ s/m).

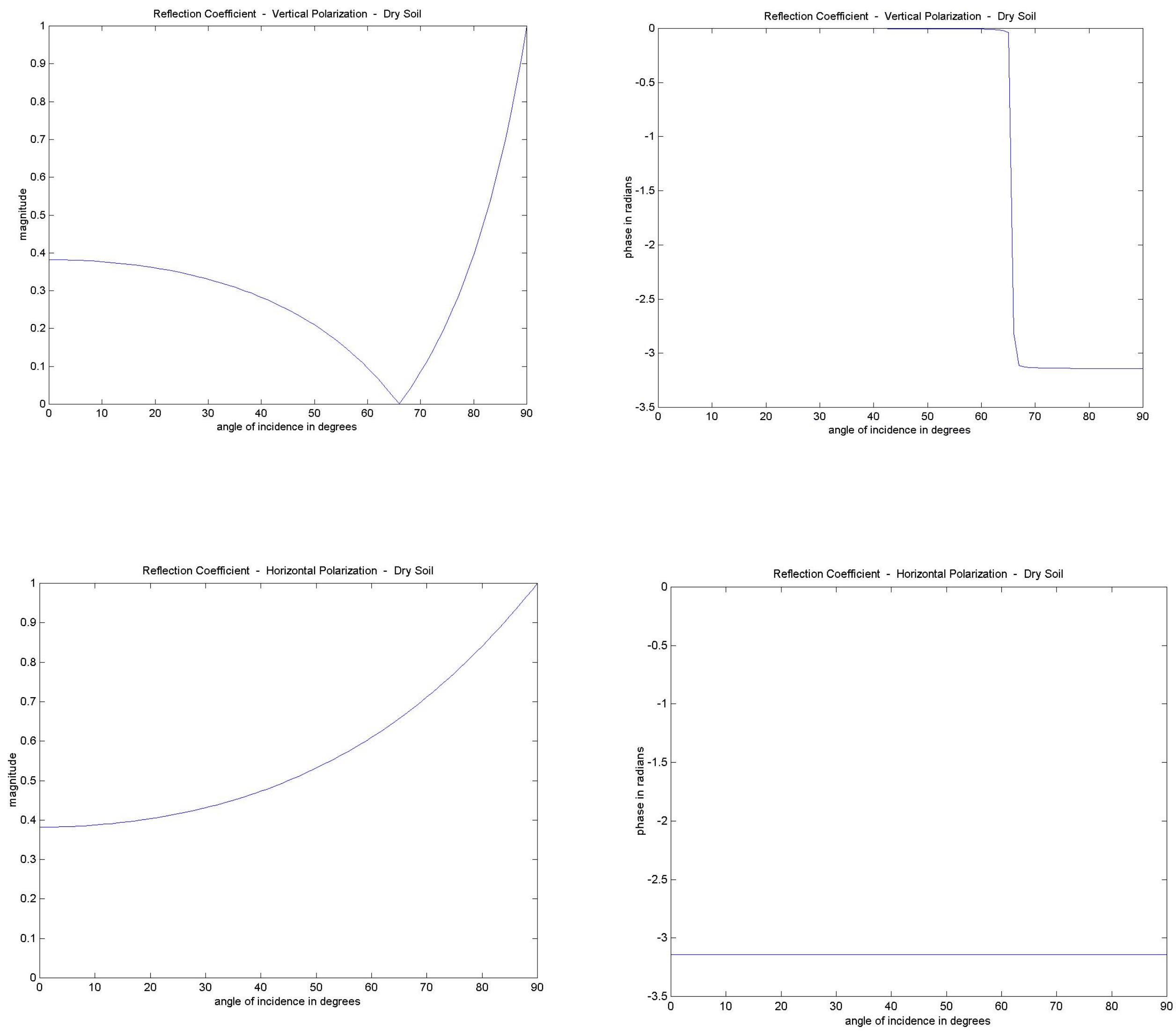

Figure 10. Magnitude and Phase of the Reflection Coefficients for Horizontal and Vertical Polarization, Dry Soil ($\sigma = 10^{-4}$ s/m).

III. DEVELOPMENT OF LAAS PRECISION APPROACH FLIGHT INSPECTION CRITERIA

Five types of assessments of the published LAAS precision approach procedure should be accomplished during flight inspection. The first assessment validates the location of any waypoints or database information used to construct or execute the approach, e.g., FPAP, TCH, LTP/FTP, etc. The second assessment relates to documenting the flyability of the procedure, while the third assessment addresses the identification of RF interference. The fourth assessment verifies the obstruction environment surrounding the procedure. The last assessment verifies the VDB coverage.

Specifications for the LAAS signal-in-space and LAAS airborne equipment were reviewed to determine which system parameters need to be recorded and which analysis is required to complete these five assessments [3,4]. At this writing, it appears that flight inspection of LAAS precision approach procedures should include the following maneuvers: flying the published approach procedure and related off-course maneuvers, performing below-procedure runs, arc maneuvers, level-pass maneuvers and orbit maneuvers.

Example flight inspection data plots (records) have been developed to aid the explanation of which system parameters need to be recorded and how these parameters can be analyzed to accomplish the five types of assessments mentioned above. Further, these example data plots are not intended to suggest any requirements or recommendations on the graphical format of the flight inspection record.

A. Approach Procedure Maneuver

The approach procedure maneuver involves flying the final approach segment of the published LAAS precision approach procedure as shown in Figure 11. Four types of assessments are performed during the approach procedure maneuver. The four assessments are: validating the location of the waypoints; documenting the flyability of the procedure; identifying the presence of RF interference; and, verifying VDB coverage.

In addition to the on-course maneuvers (CDI/VDI centered), five off-course maneuvers should be flown. Three more off-course maneuvers with the VDI full-scale fly up will be mentioned in the below path section. The five off-course maneuvers for the approach procedures are:

- An approach with the VDI centered and the CDI at full-scale fly left.

- An approach with the VDI centered and the CDI at full-scale fly right.

- An approach with the CDI centered and the VDI at full-scale fly down.

- An approach with the CDI full-scale right and the VDI at full-scale fly down.

- An approach with the CDI full-scale left and the VDI at full-scale fly down.

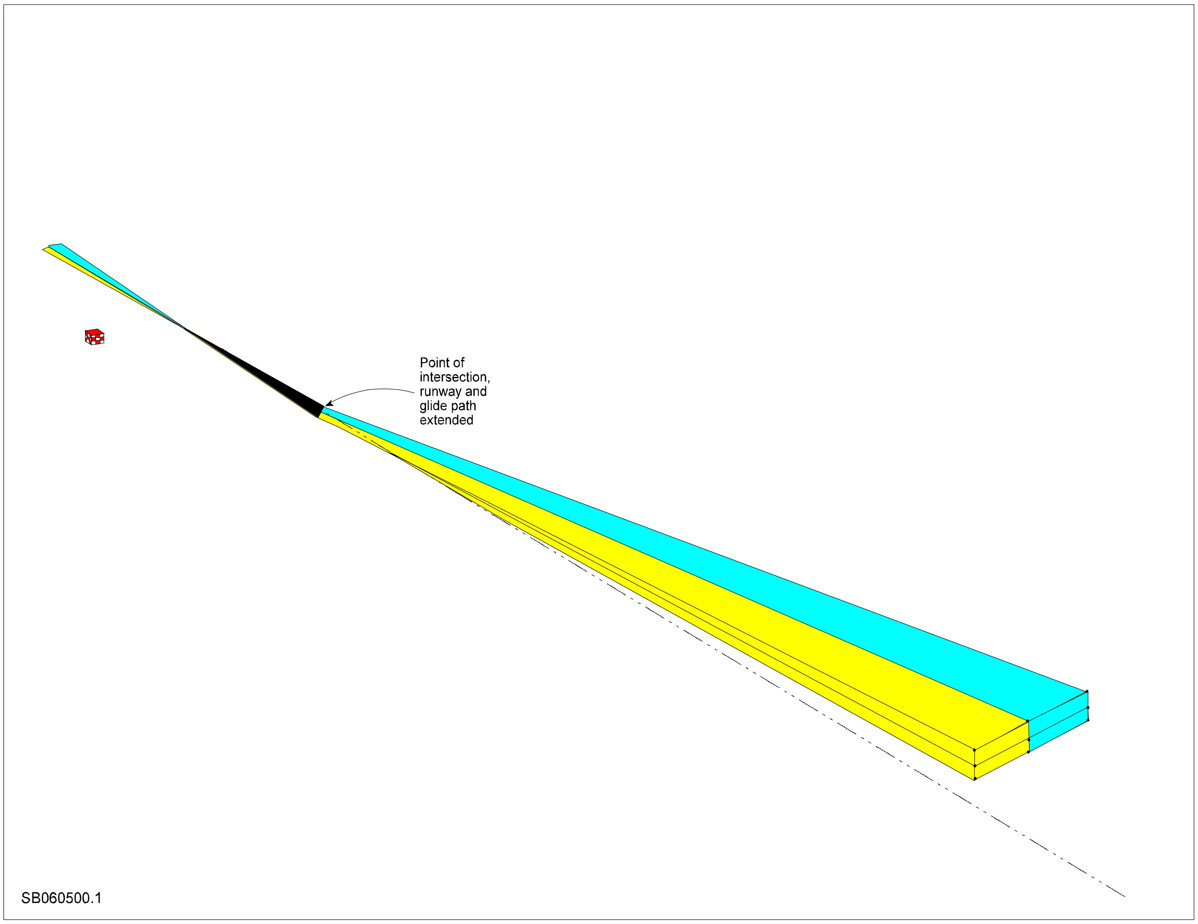

Figure 11. The Approach Maneuver Inspection Volume

Two of the five types of assessment should be performed during these off-course maneuvers. They are: identifying the presence of RF interference and verification of the VDB coverage. Part of assessing the presence of RF interference includes assessing that the appropriate full-scale deflection is indicated throughout the maneuver. These maneuvers are performed for each precision approach procedure to be supported by the subject LAAS ground facility.

Figures 12 and 13 show example flight inspection records for the approach procedure maneuver. Each of these records is comprised of a header and nine data windows. One such record would be generated to assess horizontal performance (Figure 12) and one to assess vertical performance (Figure 13). The data content and analysis to be performed using these records is explained as follows.

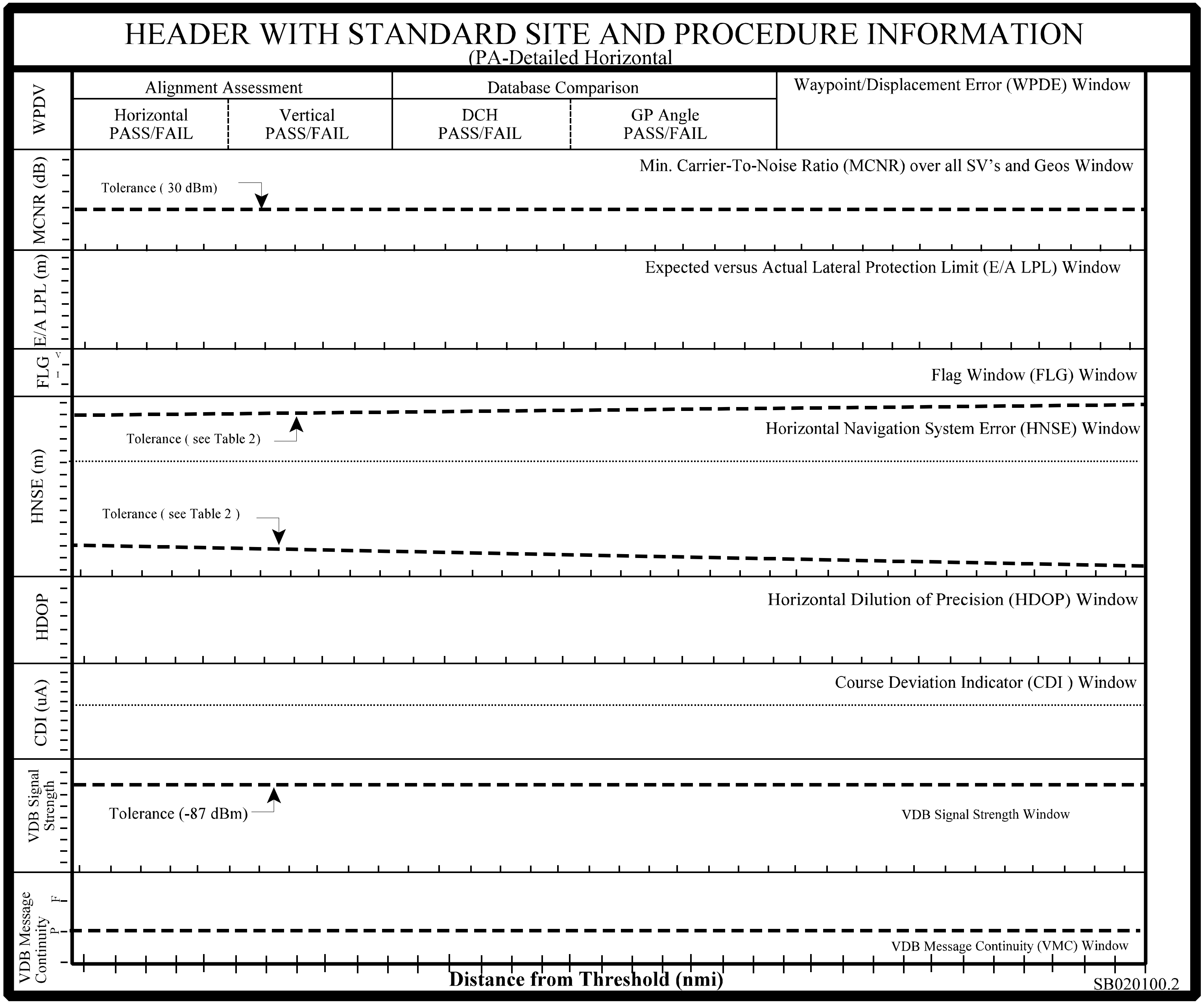

Figure 12. Example Record for the Approach Procedure Maneuver, Horizontal Performance, Detailed Format

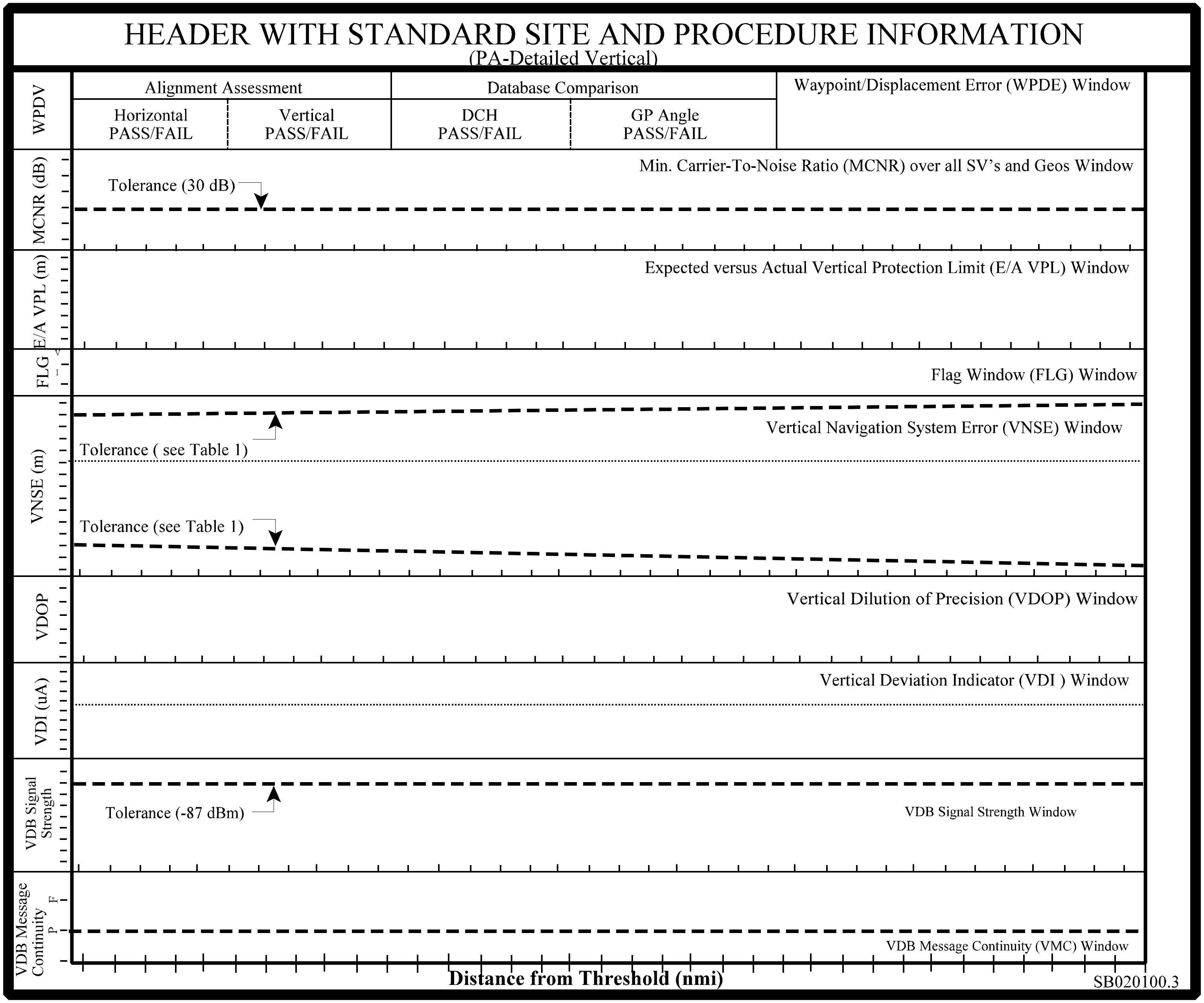

Figure 13. Example Record for the Approach Procedure Maneuver, Vertical Performance, Detailed Format

Header Block: The header (Figure 12) should consist of the standard site and procedure information used by the FAA to document flight inspection of a precision approach procedure.

Waypoint / Database Validation: The top data window (y-axis label WPDV in Figure 12) is used to present data for verifying the location of any waypoints used to construct the approach procedure. The waypoint information is obtained from the VDB. Applicable standards [3, 4] do not provide practical requirements for measuring waypoint accuracy using an airborne platform given the tolerances that are required for waypoints in the runway region. Thus, an alternate method for verifying the location of the waypoint is required.

For Category I operations, there may not be any operational benefit gained by explicitly measuring waypoint displacement error (WPDE), since the effect of WPDE on the approach procedure may be assessed sufficiently when the procedure is flown by the flight inspection aircraft. A method for performing such an assessment, as well as verifying pertinent waypoint information, is described in the following paragraphs.

The horizontal course is defined by the line containing both the LTP/FTP and the FPAP (Figure 3). These values are contained in the Final Approach Segment (FAS) Data Block which is broadcast to the user by the VDB [4]. Error in surveying or recording the values for these waypoints can result in a horizontal track that is rotated and/or offset from the desired track. Thus, the waypoint information can be verified by assessing the angular/linear alignment of the horizontal course. The assessment is performed by ensuring that the average horizontal course is within the NSE tolerance brackets, which are discussed in a subsequent paragraph. This assessment could be performed using a method similar to the one used for assessing the ILS localizer alignment [2]. The result of the assessment may be displayed as illustrated in Figure 12. The vertical course is defined by a TCH, glidepath angle, and LTP/FTP (Figure 3). The TCH and glidepath angle are obtained from the FAS Data Block [4]. Error in TCH and/or location of the LTP/FTP can result in an unacceptable actual threshold crossing height. Error in the value of glidepath angle will result in angular bias in the vertical course. Since the TCH and glidepath angle are specified values as opposed to values for surveyed locations, an independent comparison of these values should provide a sufficient assessment. In this case, the AFIS could serve as the independent reference for the correctness of the values obtained from the VDB uplink. Given the resolution specified for these values in Reference 6 and assuming the AFIS would store these data with at least the same resolution, the TCH values should agree within 0.1 feet and the glidepath angle values should agree within 0.01°.

The LTP/FTP waypoint information may be verified by assessing the alignment of the vertical course. The assessment is performed by ensuring that the average vertical course is within the NSE tolerance brackets, which are discussed in a subsequent paragraph. This assessment could be performed using a method similar to the one used for assessing the ILS glide slope alignment [2]. The result of the assessment may be displayed as illustrated in Figure 12. The achieved TCH could be compared to the desired TCH (value in FAS Data Block).

Minimum Carrier-to-Noise Ratio Window: The minimum carrier-to-noise ratio (C/N) window (y-axis label MCNR in Figure 12) is used to present data for assessing the presence of moderate

RF interference and determining if it is of operational concern. That is, interference that is not strong enough to prevent acquiring or tracking of the satellites, but may degrade LAAS performance. Although C/N_o data should be collected for all tracked satellites, only the minimum ratio obtained for each measurement set is presented. Though there was not sufficient time to accomplish a threshold analysis for this effort, operational experience indicates that the C/N_o ratio should be greater than 30 dB-Hz the vast majority of the time. Thus, a threshold of 30 dB-Hz is proposed as an initial value, until an analysis can be undertaken to determine a more suitable value.

Expected versus Actual Lateral Protection Limit Window: The expected versus actual lateral (or vertical) protection limit window (y-axis label E/A LPL in Figure 12 and E/A VPL in Figure 13) is used to assess the presence of strong RF interference and to determine if it is of operational concern. That is, interference strong enough to prevent acquiring or tracking one or more satellites. Since the satellite is not tracked, C/N_o data cannot be collected. Thus, there is a need for an additional assessment to alert the inspector to a problem. The expected lateral (or vertical) protection limit is calculated based on LAAS provided information and the satellites that should be in view at that particular time and location. The actual lateral protection level is calculated in a similar manner, except it is based on the satellites that were actually tracked. This approach assumes that the flight inspection receiver is required to track all satellites in view. The expected and actual protection limits should be nearly identical. Further work and operational experience will be required in order to establish a meaningful assessment limit(s).

Although it may be easier to determine the number of satellites tracked versus the number that should be tracked, such an approach is limited in terms of assessing the operational impact of the situation in a quantified manner.

Flag Window: The navigation flag window (y-axis label Flg in Figure 12) is used to present the status of the horizontal (or vertical) navigation sensor flag. As with other precision approach aids, the flag is expected to remain valid during the entire approach.

Lateral (or Vertical) Navigation Sensor Error Window: The lateral (or vertical) navigation sensor error window (y-axis label HNSE in Figure 12 and VNSE in Figure 13) is used to present the NSE data for assessment. The error boundaries are shown in Table 1 and Table 2 [4]. The LAAS Minimum Aviation Performance Standards specify accuracy limits for the vertical and lateral Navigation Sensor Error (NSE) and states that "the vertical Navigation Sensor Error (NSE) shall remain within the limits shown in Table 1 for 95% of the approaches out of an ensemble of approaches under any given set of conditions." A similar requirement is given for the lateral case [4]. Since at most, nine approach procedures are performed in any given flight inspection, it follows that all vertical and lateral NSE must fall within the specified boundaries in order to meet the 95% requirement.

Table 1. Vertical Navigation System Error Limit

95% Vertical NSE Limit (meters)	Height above LTP/FTP of aircraft position translated onto the final approach path (feet)
$\leq$ 4.0	100< H $\leq$ 200
$\leq$0.0117*H(ft) + 1.66	200 < H $\leq$ 1290
$\leq$ 16.7	H > 1290

Table 2. Lateral Navigation System Error Limit

95% Lateral NSE Limit (meters)	Horizontal distance of aircraft from the LTP/FTP as translated along the final approach path (meters)
$\leq$ 16.0	291< D $\leq$ 873
$\leq$0.00176*D(m) + 14.46	873 < D $\leq$ 7212
$\leq$ 27.2	D > 7212

Tables 1 and 2 are for the LAAS Type 1 Performance. Thus, these tolerances are only applicable to Category I precision approach procedures [4].

Horizontal (Vertical) Dilution of Precision Window: The horizontal (or vertical) dilution of precision window (y-axis label HDOP in Figure 12 and VDOP in Figure 13) is used to present the HDOP (VDOP) data output by the LAAS Flight Inspection Receiver. These data are presented for informational and consistency purposes. Optionally, the expected HDOP (VDOP) data may be presented in this window, also. As with the expected LPL (VPL) data, the expected HDOP (VDOP) data may be useful in assessing interference effects. In addition, the information in this window may indicate the reason for out-of-tolerance NSE or LPL data.

Course Deviation Indicator Window: The course deviation indicator window (y-axis label CDI in Figure 12) is used to present the CDI data. This data provides an indication of how well the procedure was flown. Depending on the linearity of the CDI indication (recorded sensor output), excessive flight technical error may result in inadvertently failing the waypoint displacement assessment. This situation is likely to result when the sensor CDI output scaling is “capped” or of lower resolution in the full-scale deflection region.

VDB Signal Strength Window: The VDB signal strength window is used to present the VDB signal power at the receiver input as measured by the VDB receiver which is part of the calibrated installation. The VDB signal strength at the airborne receiver input must be greater than or equal to -87 dBm. The VDB link budget accounts for worst case implementation losses for any type of aircraft utilizing either a horizontally polarized or vertically polarized antenna. The minimum power at the receiver input is specified to be -87 dBm [7]. In some cases, the receiver may output automatic gain control (AGC) level rather than calibrated signal strength in dBm. In this case, the flight inspection system vendor should convert the AGC data to a calibrated signal strength in dBm before plotting the results in this window.

For a given performance parameter (e.g., VDB signal strength), four trends may be observed in the approach and off-course plots. Two of the trends are: 1) pass, and, 2) fail. Figure 14 indicates the case where all runs clearly pass. In this case, on periodic inspection, only the approach maneuver (3º centerline) is required to be performed.

A third case involves the majority of the runs pass but one of the off-course procedures is marginal (Figure 15). In this case, on periodic inspection, the approach maneuver is flown along with the off-course maneuver which was marginal during commissioning.

The fourth case involves the majority of the runs pass but one of the off-course maneuvers shows a distinctively different trend (Figure 16). As with the third case, on periodic inspection, both the approach procedure and the unusual off-course maneuver should be flown.

VDB Message Rate Window : This window provides a binary indication of message rate continuity. Although the VDB signal strength will be evaluated, it is more important to evaluate VDB message continuity. This statement arises from considering that it may be possible for multipath to corrupt the message content even though the signal strength remains at an acceptable level.

The LAAS Ground Facility Specification [3] and the LAAS airborne MOPS [7] state that the message failure rate shall be less than or equal to one failed message per 1000 full-length (222 bytes) application data messages. For flight inspection, a 500-second long sliding window (i.e., 1000 measurements at a rate of 2/sec) shall be used to evaluate this requirement. During the flight inspection mission, at any given time, the 500-second sliding window should not have two or more failed messages. The message rate window will indicate ‘P’ (pass) if zero or one message has failed within the window. If two or more messages have failed within any window, then the message rate window will indicate ‘F’ (fail).

There are various ways to present the required data and analysis. Some suggestions are provided in this paragraph. The example flight inspection records shown in Figures 12 and 13 are intended to provide a reasonably detailed assessment of the approach procedure from a flight inspection perspective. Optionally, Figure 17 shows a more basic format that could be used for the approach maneuver. This format presents only the data necessary for making a pass/fail determination, and it presents the horizontal and vertical performance data on the same record. The formats shown in Figures 12 and 13 could be used for commissioning flight inspection missions, where a more thorough assessment of the procedure is desired. In addition, these

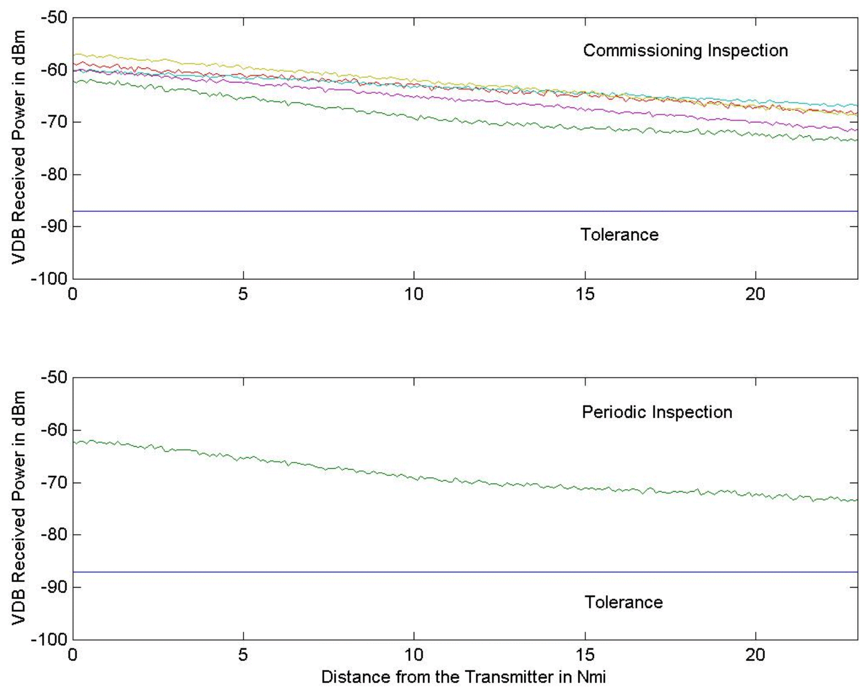

Figure 14. Sample Plots for the Clear Pass on the Approach Maneuver

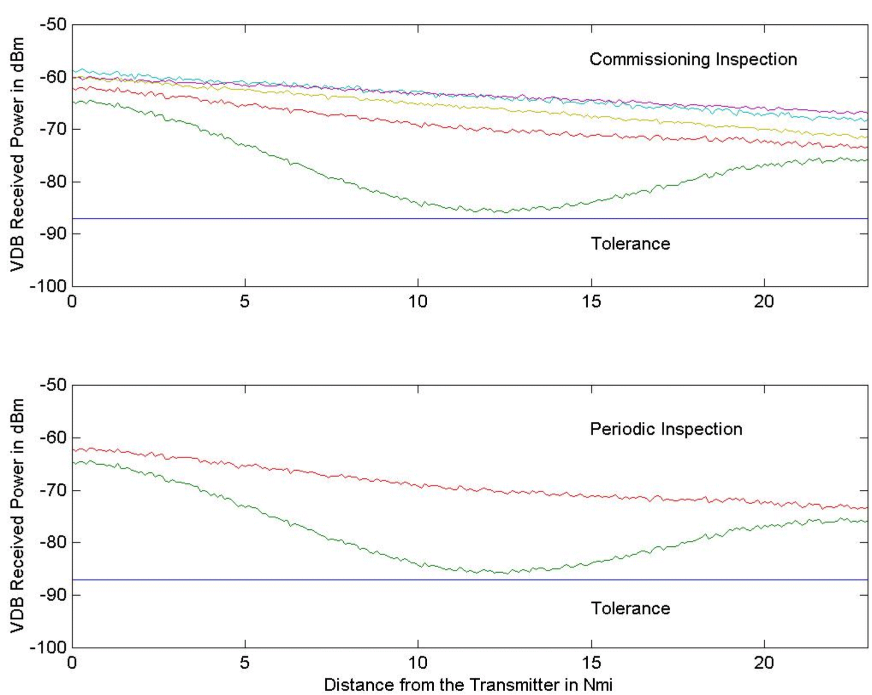

Figure 15. Sample Plots for the Marginal Case on the Approach Maneuver

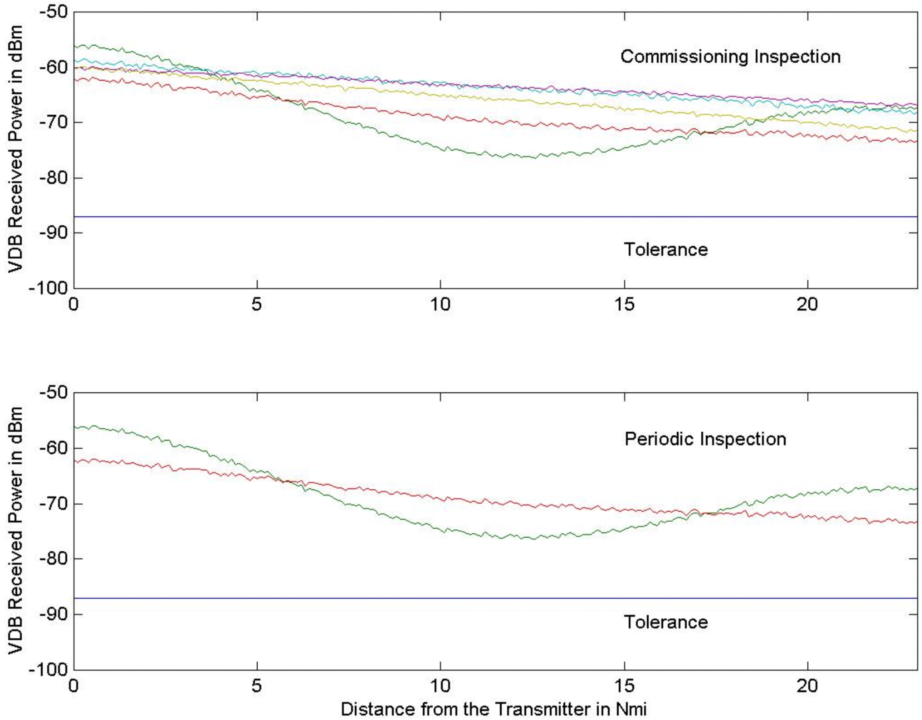

Figure 16. Sample Plots for the Unusual Case in the Approach Maneuver

formats could be used to enable further assessment of the situation when the more basic format indicates an out-of-tolerance condition. The format shown in Figure 17 could be used for periodic flight inspection missions.

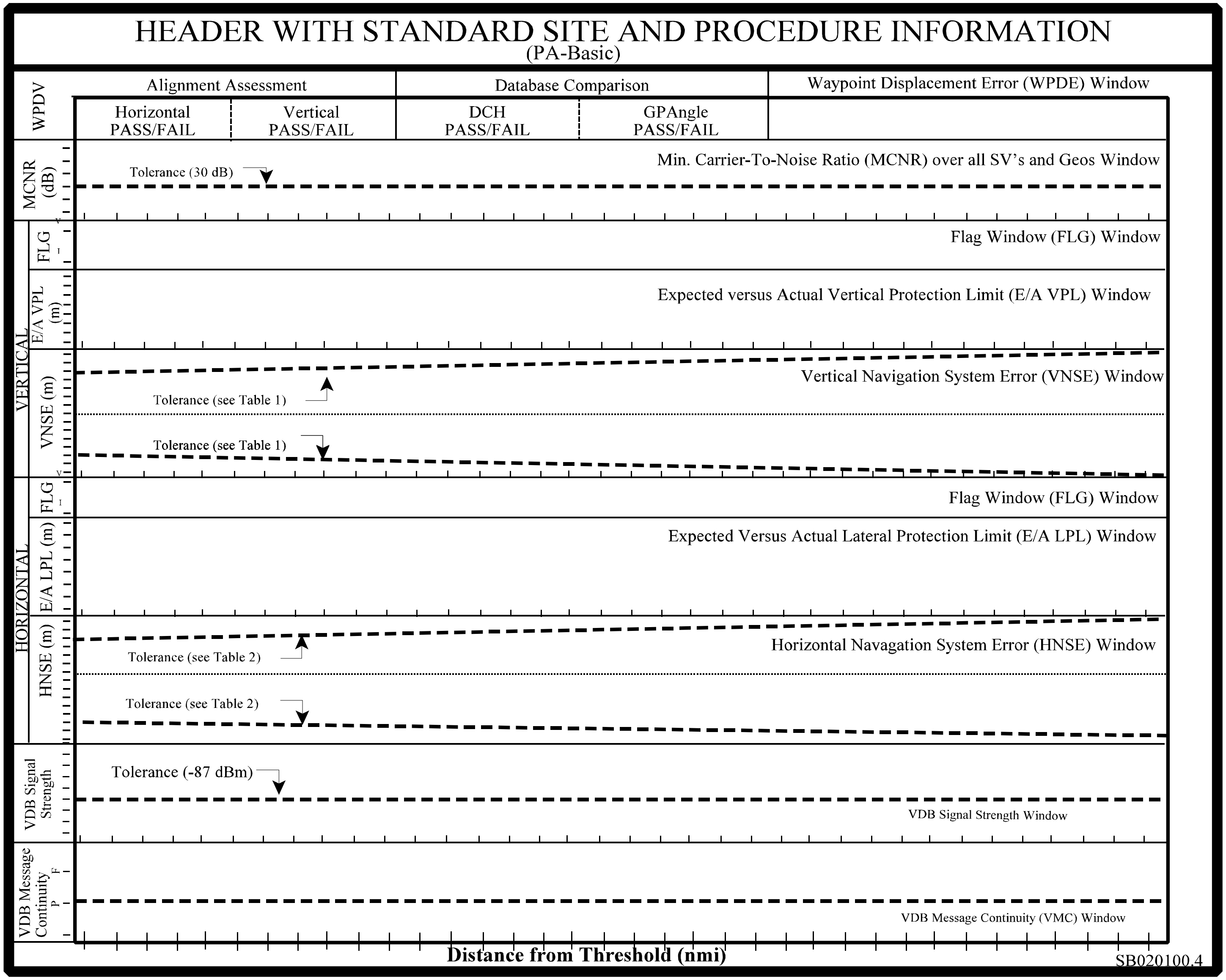

Figure 17. Example Record for the Approach Procedure Maneuver, Basic Format

B. Below Path Maneuver

The below path maneuver involves flying straight-line segments with specified horizontal and vertical profiles. The below path maneuver is performed routinely along the procedure horizontal track (normally centerline extended) as described below:

- An approach with the CDI centered and the VDI at full-scale fly up.

During commissioning, additional below path maneuvers are performed as described below:

- An approach with the CDI full-scale fly right and the VDI at full-scale fly up

- An approach with the CDI full-scale fly left and the VDI at full-scale fly up.

As with the approach and off-course maneuvers (described in the previous section), below path maneuvers which are marginal or significantly different should be repeated during periodic inspections.

Three of the five types of assessment are performed during the below path maneuver. The three assessments are: verifying the obstruction environment, identifying the presence of RF interference, and verifying VDB coverage. Part of assessing the presence of RF interference includes assuring that a full fly-up indication is provided below the approach procedure. These maneuvers are performed for each precision approach procedure to be supported by the LAAS ground facility under test.

Figure 18 shows an example flight inspection record for the below path maneuver. This record consists of a header block and eight data windows. One such record is generated for each below path maneuver performed. The header block and the MCNR, FLG, E/A LPL, E/A, VP, VDB signal strength, and VDB message rate windows are utilized in the same manner as discussed above for the approach procedure maneuver.

Local Area Augmentation System Vertical Deviation Indicator Window: The LAAS vertical deviation indicator window (y-axis label LAAS VDI in Figure 18) is used to present the LAAS-based vertical-deviation indicator data for assessment during below path maneuvers. That is, the vertical-deviation data is provided by the LAAS flight-inspection receiver, which is using the published waypoint information.

Maneuver Course Deviation Indicator/Vertical Deviation Indicator Window: The maneuver course deviation indicator/vertical deviation indicator window (y-axis label Maneuver CDI/VDI in Figure 18) is used to present the course/vertical deviation data (two data traces) corresponding to the particular below path maneuver. These data document how well the intended below path maneuver profile was flown. In this case, it is assumed that a separate guidance system/set-up is used to provide guidance information relative to the intended below path maneuver.

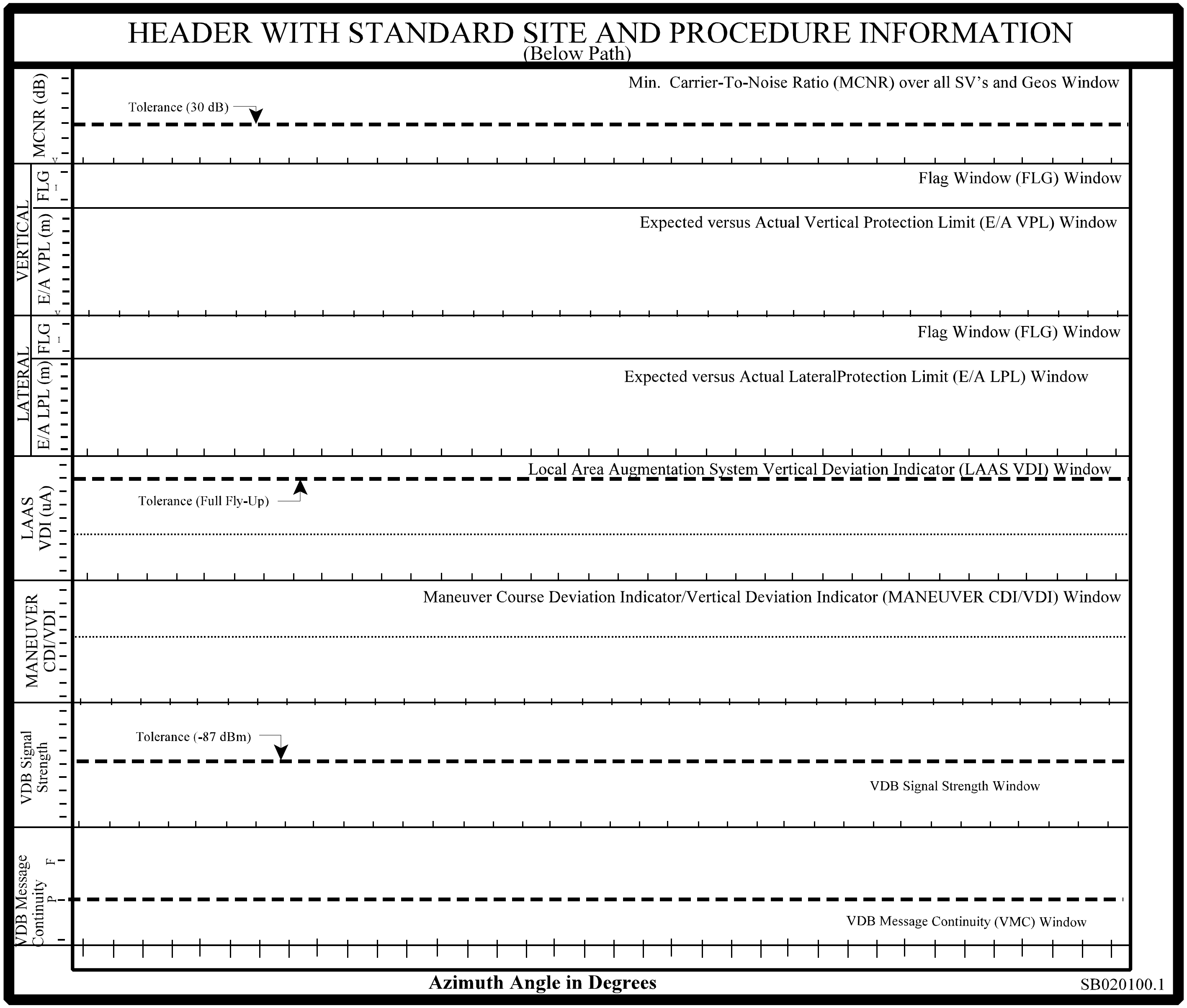

Figure 18. Example Record for the Below Procedure Maneuver

C. Orbit Maneuver

The orbit maneuver is used primarily to check the lateral VDB coverage volume of the LAAS. The orbit maneuver involves flying a circular track, at a constant altitude, around the VDB transmit antenna. Two of the five types of assessment are performed during the orbit maneuver. The two assessments are: verifying the VDB coverage in the TAA, and identifying the presence of RF interference. The coverage volume is depicted in Figure 4 [3]. Unlike the other maneuvers discussed in this section, the orbit maneuvers are performed for each ground facility under test regardless of the number of approach procedures supported.

Orbits are required at the extremes of the VDB coverage volume. Thus orbits should be performed at a distance of 23 nautical miles from the transmit antenna at an altitude of 2000 feet. If the data collected during this maneuver is within tolerance, then the maneuver should be repeated at an altitude of 10,000 feet. However, at many facilities clear line-of-sight (LOS) from the VDB transmit antenna to the lower extreme coverage limit may not exist for the entire 360 degrees of azimuth. Such situations may cause unavoidable outages of the VDB signal during inspection of the lower coverage limit. In this case, an additional orbit should be performed at the lowest altitude where clear LOS from the VDB transmit antenna to the lower extreme coverage limit exists for the entire 360 degrees of azimuth. The minimum LOS altitude may be determined by performing a horizon survey at the VDB transmit antenna site.

Figure 19 shows an example of the flight inspection record for the orbit maneuver. This record consists of a header block and three data windows. One such record is generated for each orbit maneuver. The MCNR, VDB signal strength and VDB message rate windows are utilized in the same manner as discussed in the approach section.

If any of the MCNR, VDB signal strength or VDB message rate windows indicate the presence of interference, then the range of azimuths in which interference is found should be determined. Radials (inbound) in the affected region should be performed to determine the extent of the interference.

D. Arc Maneuver

In addition, three partial orbits (arcs) should be performed within the lateral proportional guidance region (from full-scale fly right to full-scale fly left) at 23 nautical miles from the VDB transmit antenna. These maneuvers are performed for each precision approach procedure to be supported by the subject LAAS ground facility.

One arc should be performed with the VDI at full-scale fly up, one with the VDI centered, and one with the VDI at full-scale fly down. If the VDB signal fluctuations are encountered at a particular point on one of these maneuvers, a radial at that azimuth and elevation angle should be flown to determine the nature and extent of the problem.

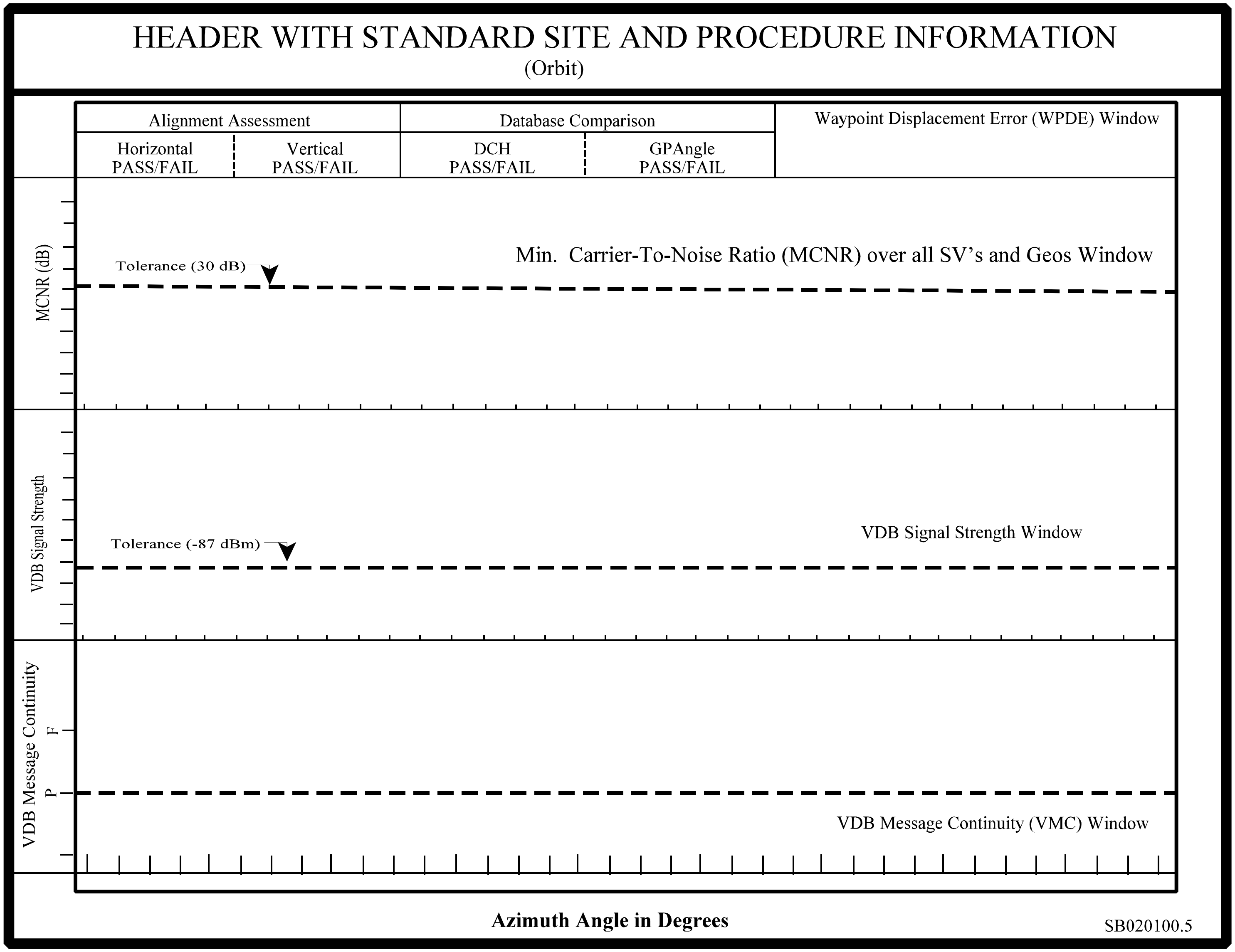

Figure 19. Example Record Format for the Orbit Maneuver

During the periodic inspection, only the full-scale fly up maneuver is to be flown. However, if marginal or unusual performance is noted on one or both of the other two orbits during commissioning, then these should also be repeated during the periodic inspections.

E. Level-Pass Maneuver

The level-pass maneuver involves flying a radial of the VDB transmit antenna at a constant altitude. Two of the five types of assessment are performed during the level-pass maneuver. The two assessments are: verifying the VDB coverage in the TAA and the approach region, and identifying the presence of RF interference. These maneuvers are performed for each precision approach procedure to be supported by the subject LAAS ground facility.

The level-pass should be performed starting at the edge of the coverage volume (which is at 23 nautical miles), flying inbound to the VDB transmit antenna. The minimum altitude for the level-pass is 2000 feet. However, in the presence of obstructions, the level-pass should be performed at an altitude sufficiently high to maintain a clear line-of-sight between the VDB transmit antenna and the flight inspection aircraft. A level pass should also be performed at the minimum descent altitude (MDA) corresponding to the final approach fix (FAF).

The level-pass maneuver assesses the VDB antenna lobing, thus the received VDB signal strength is a key parameter. The signal strength should drop below the tolerance level only when the receiver is in the cone-of-silence above the VDB transmit antenna.

Figure 20 shows an example flight inspection record for the level pass maneuver. This record consists of a header block and three data windows. One such record is generated for each level-pass maneuver. The MCNR, VDB signal strength, and VDB message rate windows are utilized in the same manner as discussed in the approach section.

F. Summary of Maneuvers

The candidate flight inspection maneuvers discussed in this report are listed in Table 3. As proposed, all of the maneuvers would be performed for the commissioning inspection of a LAAS ground facility. It is anticipated that periodic flight inspection of LAAS ground facilities will be required for two purposes. The first purpose is to ensure that there has not been any degradation of the VDB coverage due to environmental changes or equipment repair/replacement. The second is to ensure that new sources of RF interference have not come into existence. Table 3 provides recommendations upon which maneuvers should be included when performing a periodic inspection.

The number of commissioning maneuvers being recommended in this report is notably higher than the number that would typically be performed for Instrument Landing System (ILS) or Microwave Landing System (MLS) facilities. This situation is especially true for the number of commissioning approach and off-course maneuvers. The rationale for this situation is provided below.

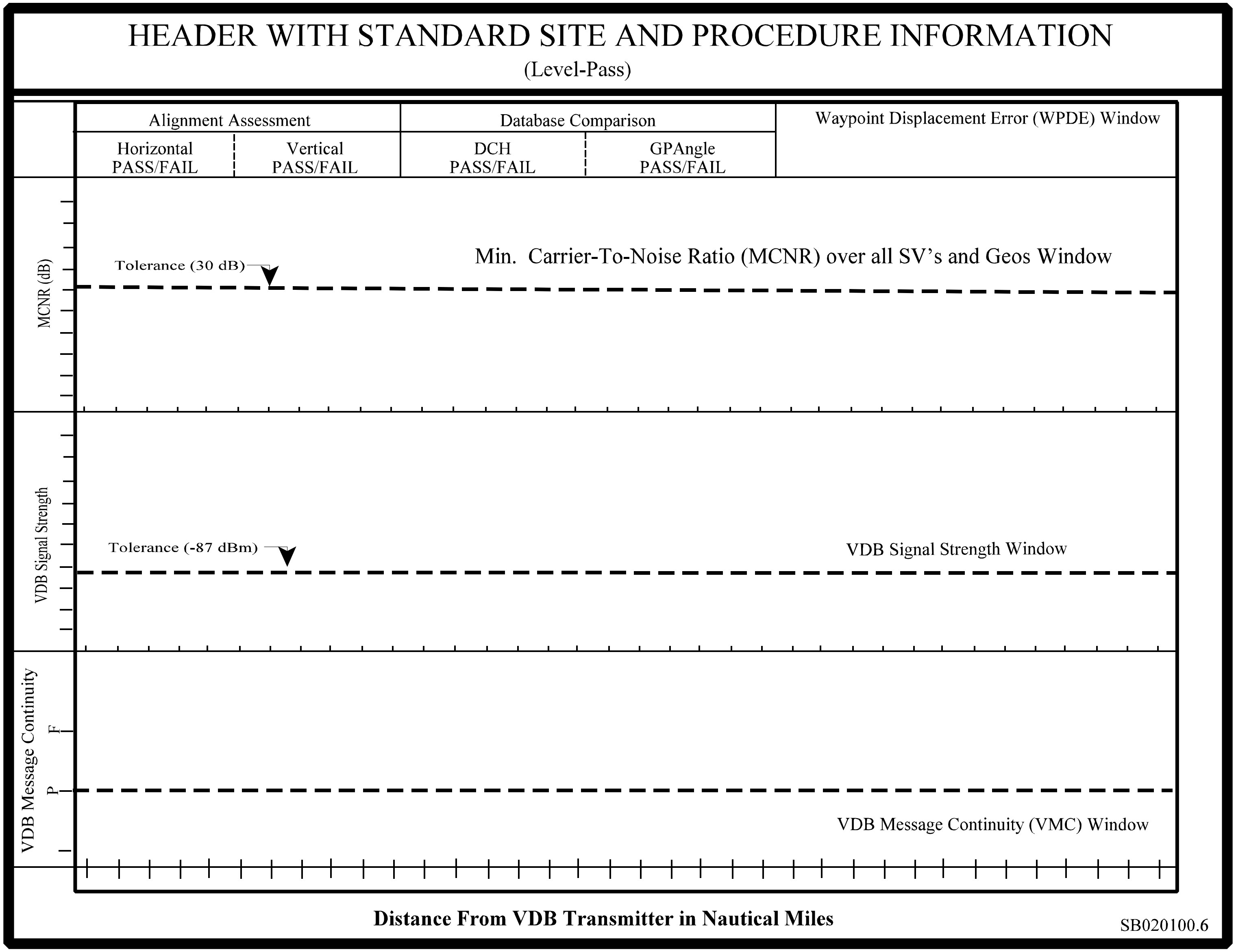

Figure 20. Example Record for the Level-Pass Maneuver

Table 3. Flight Maneuvers Check List

Procedures	Commissioning	Periodic	VDB Equipment or Frequency Change
Approach Maneuvers			
VDI center, CDI full-scale fly left	x	x	x
VDI center, CDI full-scale fly right	x	1,2	x
CDI center, VDI full-scale fly down	x	1,2	x
CDI full-scale fly right, VDI full-scale fly down	x	1,2	x
CDI full-scale fly left, VDI full-scale fly down	x	1,2	x
Below-path Maneuvers			
CDI center, VDI full-scale fly up	x	x	x
CDI full-scale fly right, VDI full-scale fly up	x	1,2	x
CDI full-scale fly left, VDI full-scale fly up	x	1,2	x
Arc Maneuvers			
VDI full-scale fly down, and in lateral proportional guidance region	x	1,2	x
VDI center, and in lateral proportional guidance region	x	1,2	x
VDI full-scale fly up, and in lateral proportional guidance region	x	x	x
Orbit Maneuvers			
At 23 nautical miles, and 2000 feet altitude or minimum line of sight from the VDB antenna (site dependent)	x	x	x
At 23 nautical miles, 10,000 feet altitude	x	1,2	x
Level-pass Maneuvers			
At 3^{o} approach with the minimum line of sight	x	x	x
At 2000 feet altitude inbound	x	x	x

x Required
1 This procedure should be repeated in periodic flight if the performance during commissioning is marginal.
2 This procedure should be repeated in periodic flight if the performance during commissioning has a different trend than the rest.

The heart of the matter is the variation in siting configurations for the LAAS VDB antenna compared to the ILS/MLS antennas. Typically, the ILS/MLS antennas are sited in relatively close proximity to the runway and their principle direction of radiation during the approach procedure is along the runway centerline extended. Thus, these systems inherently have a very clean propagation “corridor”. Thus, there is technical justification, backed by decades of experience, that if these systems fly well below path one can be confident that they will perform well when on path or above path.

Although validated siting criteria have not been developed at this time for the VDB antenna, it is anticipated there will be more flexibility in siting the VDB antenna compared to ILS/MLS antennas. In developing the flight inspection concepts presented in this report, it was not assumed that the VDB antenna siting would be constrained to locations in close proximity to the runway. This increase in siting flexibility brings the potential for more variability in the characteristics of the signal-in-space from site to site, or even for different approach procedures supported by the same LAAS ground facility. This situation is further compounded by the relatively limited experience the aviation community has with siting and flight inspection when this type of equipment is used to support precision approach operations. The investigation of the matter is still further hindered by the lack of a validated LAAS multipath model.

As a result, the number of maneuvers recommended reflects the conservative approach used to develop the flight inspection concepts presented herein. In addition, it is anticipated that further investigation of these matters, validation of the concepts presented herein, and experience gained over time will support a reduction in the number of maneuvers that need to be performed.

IV. DATA COLLECTION/REDUCTION REQUIREMENTS

Appropriate data reduction algorithms shall be developed for the Automated Flight System (AFIS) to support the flight inspection event(s). It is anticipated that data elements from the LAAS receiver and information from the aircraft flight management system, as well as some manually entered data, will be used to accomplish this task. The information available through data reduction, the so-called derived data, along with truth data supplied through the AFIS, will be used to generate the actual flight inspection records.

A. Essential Data Elements for Flight Inspection

1. Position (ecef or llh), velocity (m/s) and heading (rad) with time tags -- source: LAAS Receiver

2. C/N_o (dB-Hz) for all SVs (GPS and GEO) used in the position solution with time tag -- source: LAAS Receiver

3. VDOP, HDOP (value) with time tag -- source: LAAS receiver

4. VPL_{LAAS}/LPL_{LAAS} (m) with time tag -- source: LAAS receiver

5. VDB signal strength with time tag–source: VDB receiver

B. Auxiliary Data Elements for Diagnostic/Historical Usage

1. Pseudorange (m), C/N_o (dB-Hz), Carrier Phase (count), Ephemeris Data (record), Smoothed Pseudorange (m) for all SVs (GPS and GEO) tracked: all elements with applicable time tag -- source: LAAS receiver

2. LAAS message(s) with time tag -- source: VDB receiver. From ICD .

B. Derived Data

1. HEADER BLOCK -- consistent with AFIS identification data and FAA requirements

2. Waypoint displacement error(s) (units consistent with HEADER BLOCK)

3. Minimum C/N_o (dB-Hz) of all SVs used in position solution versus distance from threshold (nmi)

4. Horizontal Navigation Sensor Error (m) versus distance from threshold (nmi)

5. Expected {HDOP,VDOP} (value) versus distance from threshold (nmi)

6. CDI(μA)/FLG (discrete) versus distance from threshold (nmi)

7. Vertical Navigation Sensor Error (m) versus distance from threshold (nmi)

8. VDI(μA)/FLG (discrete) versus distance from threshold (nmi)

9. VDB message rate (note: the AFIS must examine the time tags of successive valid VDB messages)

V. CONCLUSIONS AND RECOMMENDATIONS

Provisional flight inspection concepts have been developed for the inspection of the LAAS precision approach procedures. These concepts are intended to be applied to the Final Approach Segment; inspection of all other segments should be accomplished by using the applicable criteria for C129 procedures (need more formal reference).

The following recommendations are offered for consideration:

- Further work should be performed to assess the suitability of the tolerance proposed for the minimum carrier-to-noise ratio data. This work should review receiver performance and certification requirements, as well as the assumed LAAS interference mask to determine the suitability of the 30 dB-Hz tolerance that has been proposed.

- The practicality of implementing the proposed-flight inspection criteria in a routine, day-to-day manner should be assessed. Flight trials should be performed to assess the feasibility of implementing these criteria, as well as identify shortcomings and efficiency issues.

-VDB site feasibility testing should be conducted as part of the LAAS ground facility siting work. It should be noted that this type of testing can be performed with a flight test package that would be simpler than that required for the usual flight inspection work. Such testing should reduce the number of failed commissioning flight inspections due to VDB signal coverage problems.

- After the LAAS Category I Flight Inspection Criteria has been approved and implemented, it is important to evaluate the LAAS Category II and III capability and attendant flight inspections certification requirements.

- The development of appropriate procedures for inspection of LAAS-supported airport surface operations should be addressed in the near term by the appropriate FAA authority.

VI. REFERENCES

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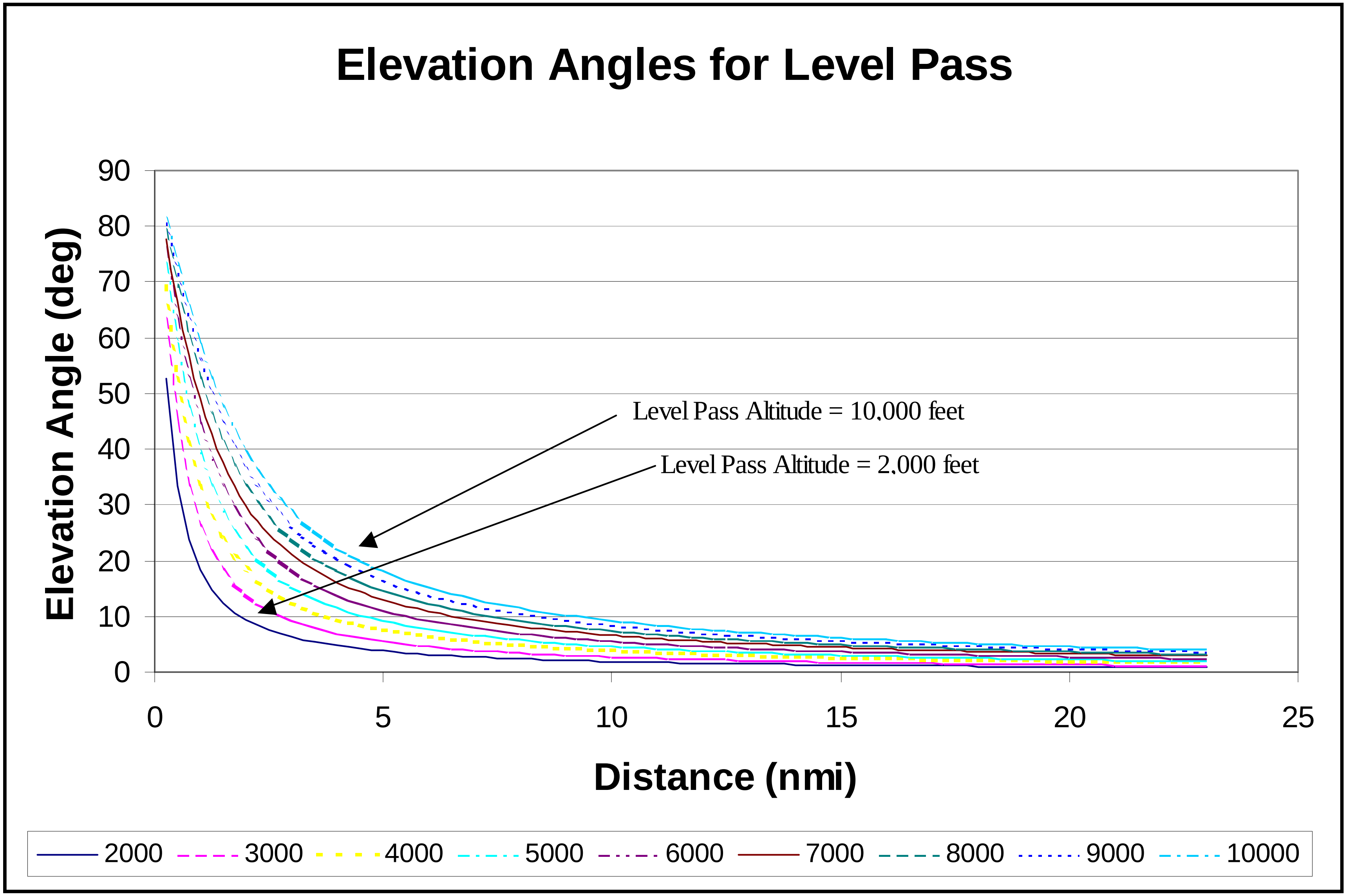
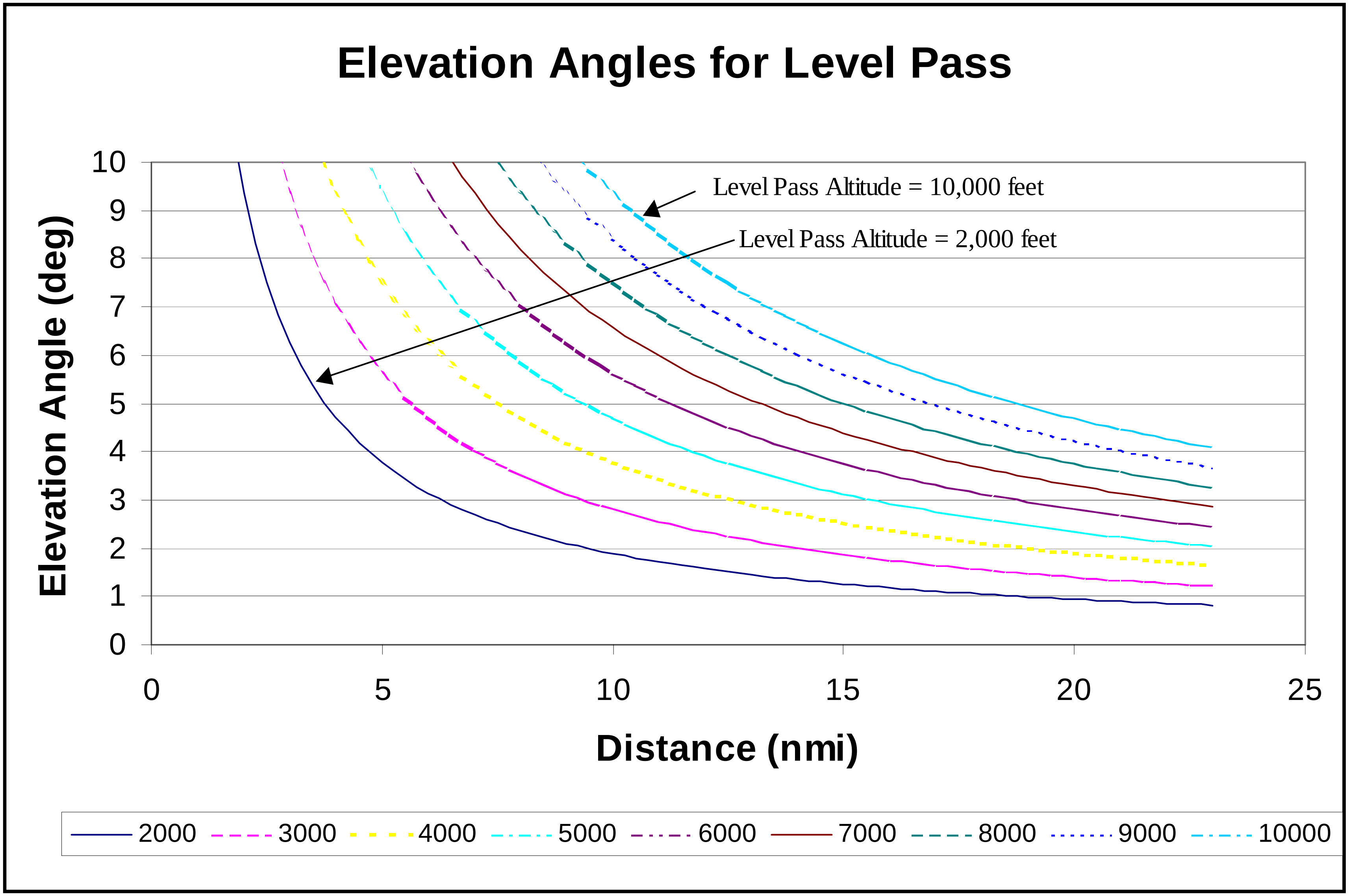
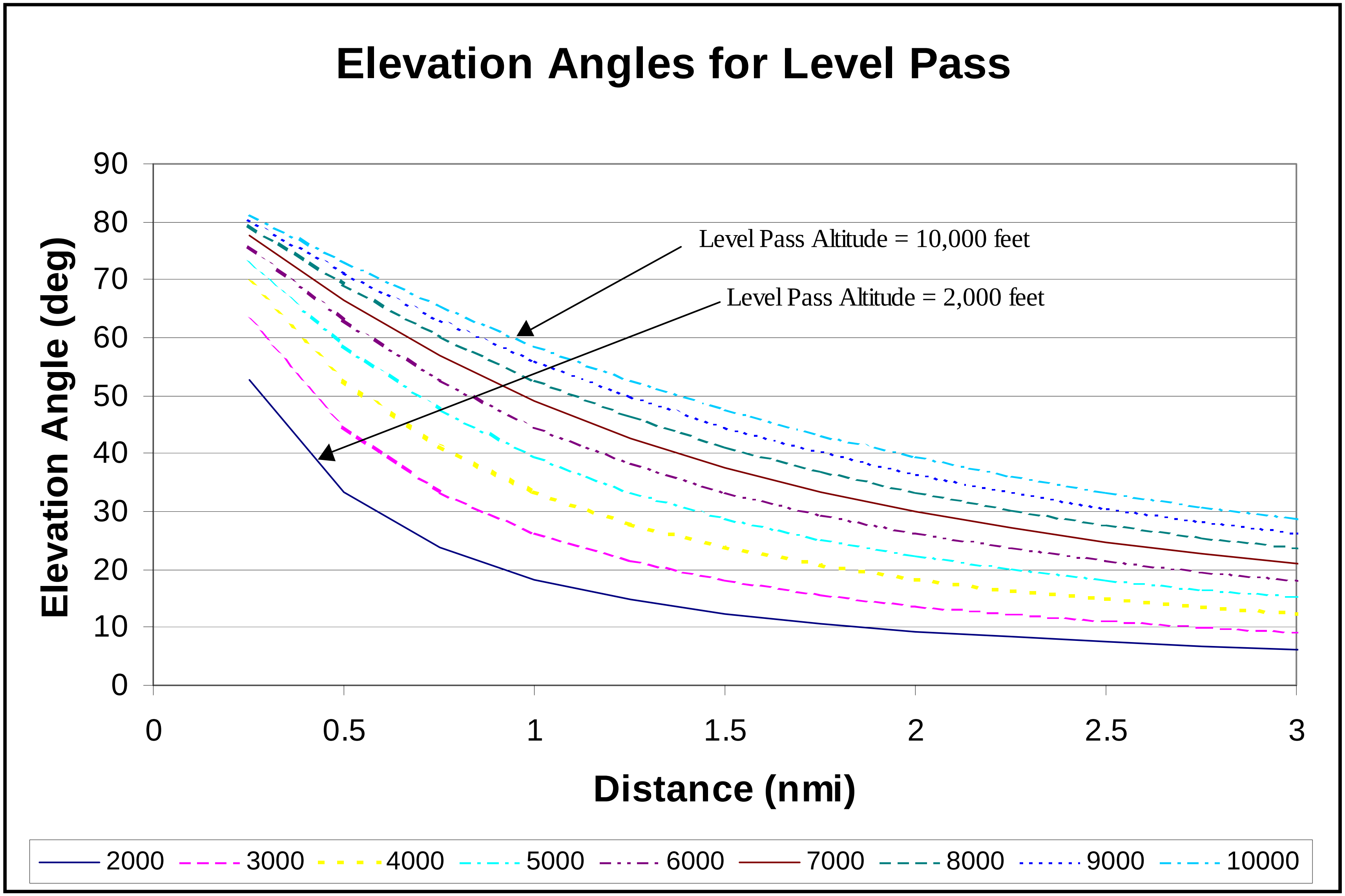
APPENDIX A

Elevation Angles Versus Level-Pass Altitude


Elevation Angles for Level Pass
Elevation Angle (deg)
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
25
Distance (nmi)
Level Pass Altitude = 10,000 feet
Level Pass Altitude = 2,000 feet
2000
3000
4000
5000
6000
7000
8000
9000
10000


Elevation Angles for Level Pass
Level Pass Altitude = 10,000 feet
Level Pass Altitude = 2,000 feet
Elevation Angle (deg)
0
1
2
3
4
5
6
7
8
9
10
0
5
10
15
20
25
Distance (nmi)
2000
3000
4000
5000
6000
7000
8000
9000
10000

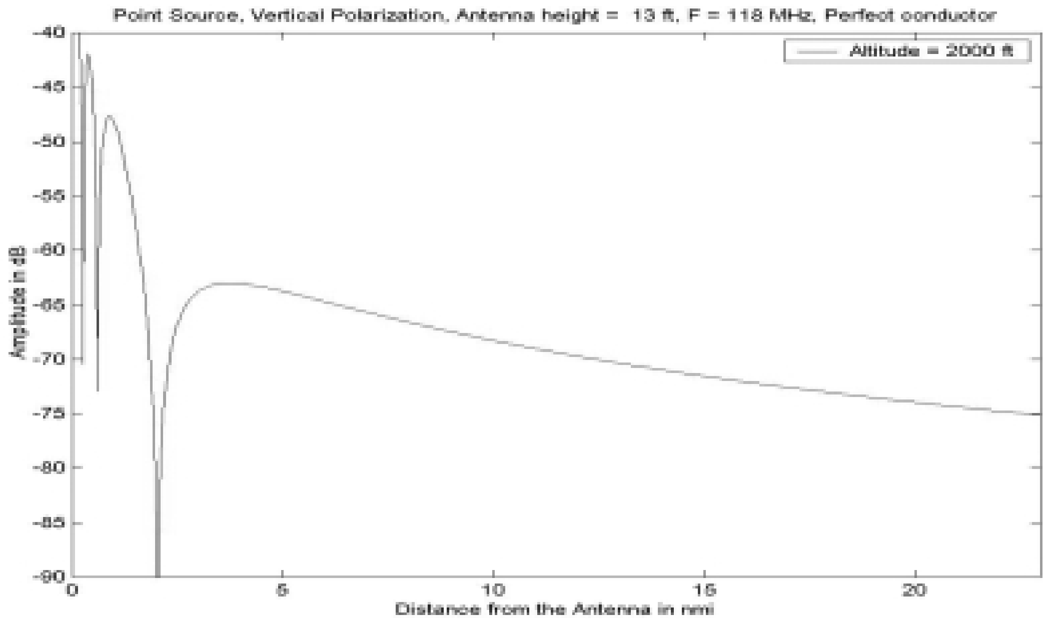

Elevation Angles for Level Pass
Elevation Angle (deg)
0
10
20
30
40
50
60
70
80
90
0
0.5
1
1.5
2
2.5
3
Distance (nmi)
Level Pass Altitude = 10,000 feet
Level Pass Altitude = 2,000 feet
2000
3000
4000
5000
6000
7000
8000
9000
10000

APPENDIX B

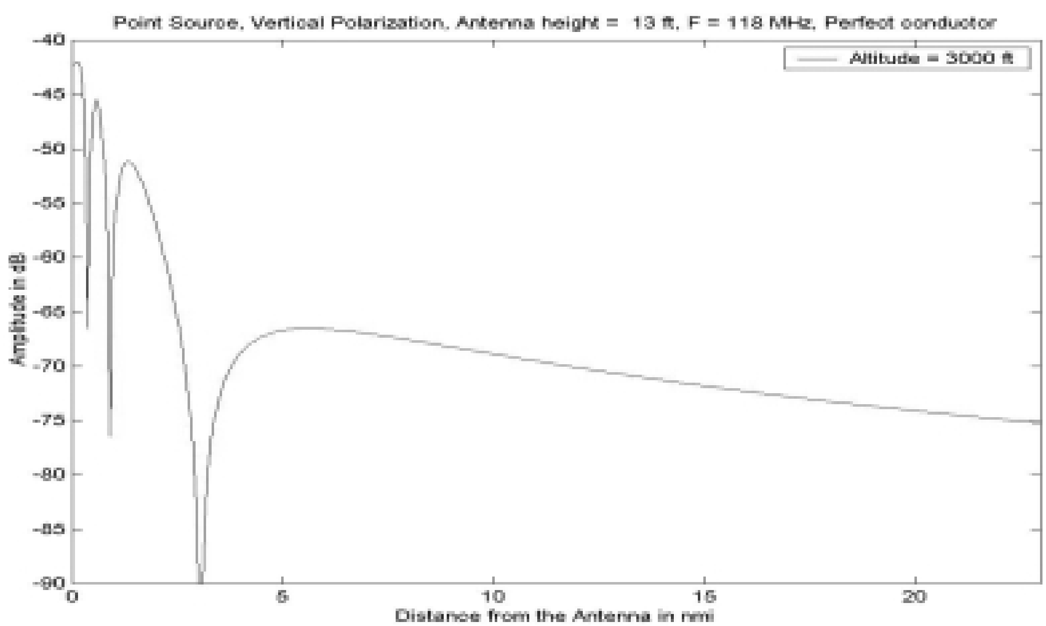
Receiver Power Versus Level-Pass Distance

The plots in this appendix represent a complete listing of the analysis of the interaction between the VDB transmit antenna and the ground plane. Four parameters are considered:

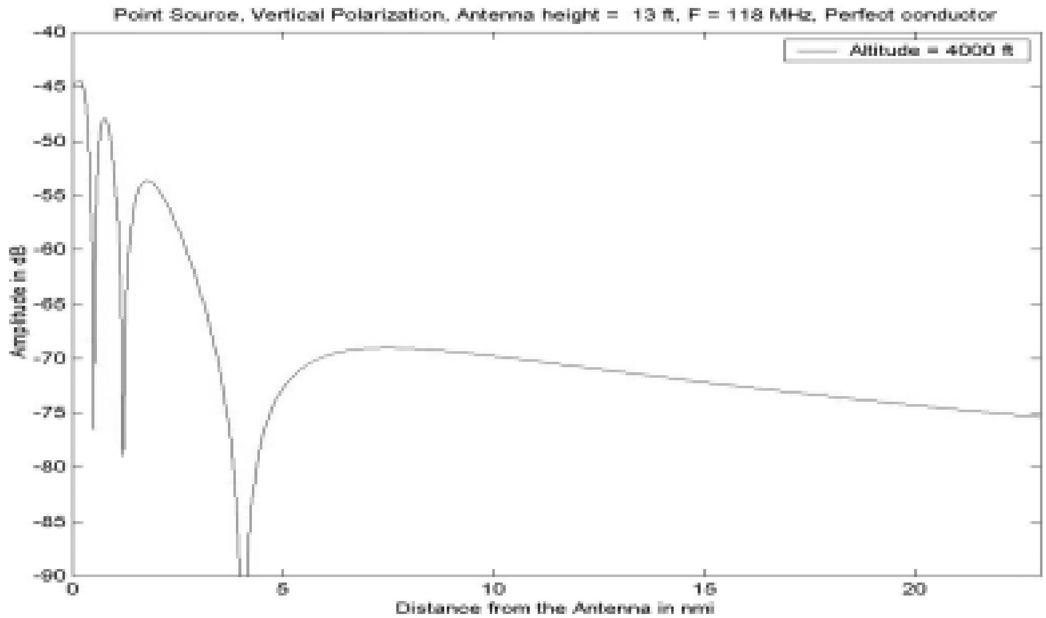
1. VDB transmit antenna phase-center height-above-ground.
2. Level-pass altitude.
3. Ground-plane material (conductivity).
4. Polarization.

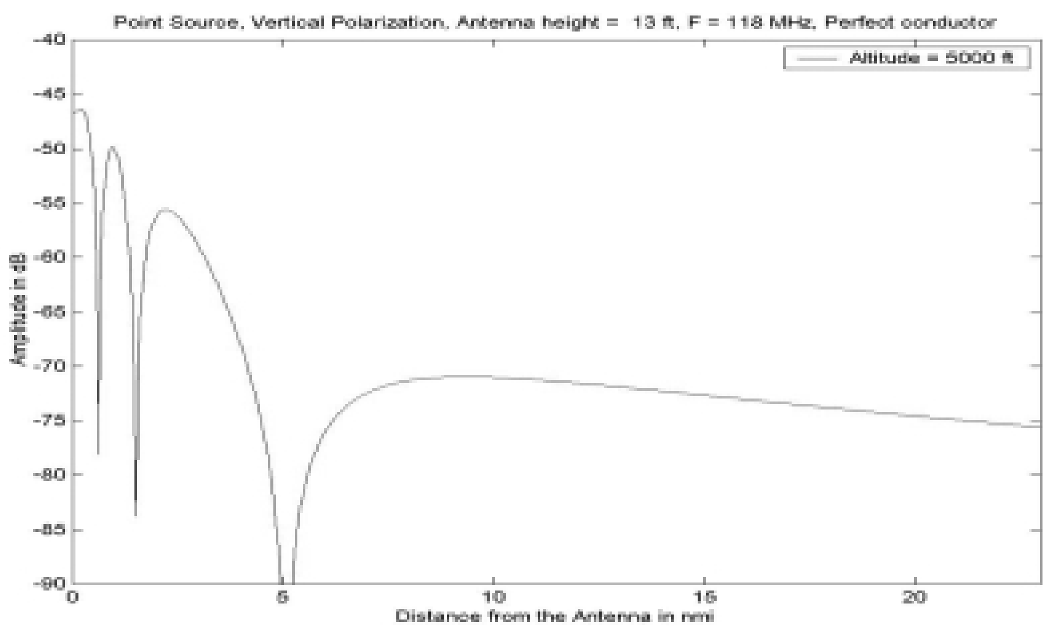


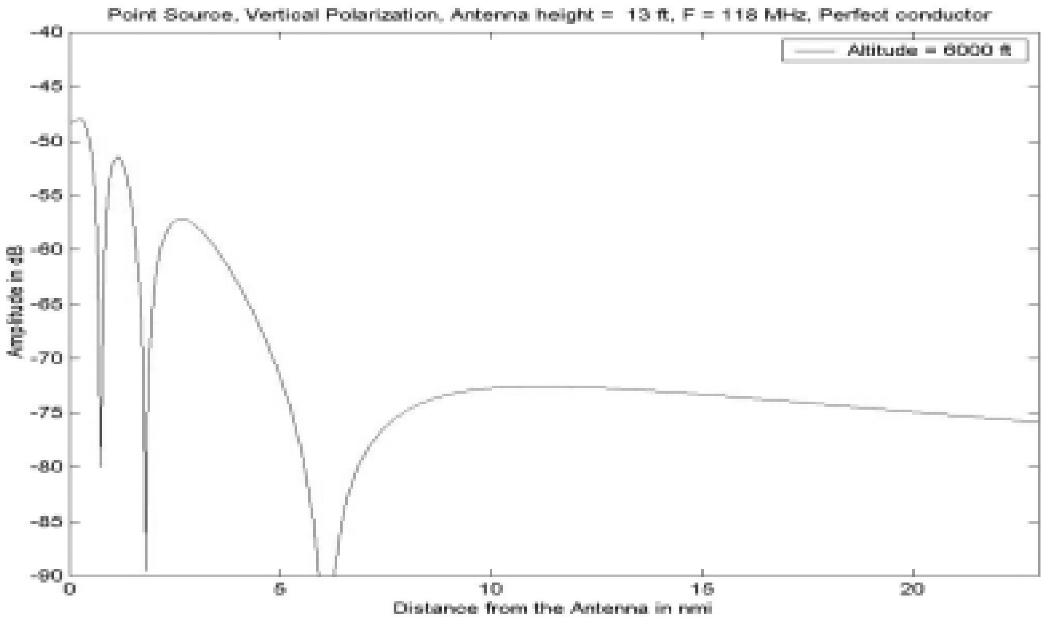
Point Source, Vertical Polarization, Antenna height = 13 ft, F = 118 MHz, Perfect conductor
Altitude = 2000 ft
Amplitude in dB
Distance from the Antenna in nmi

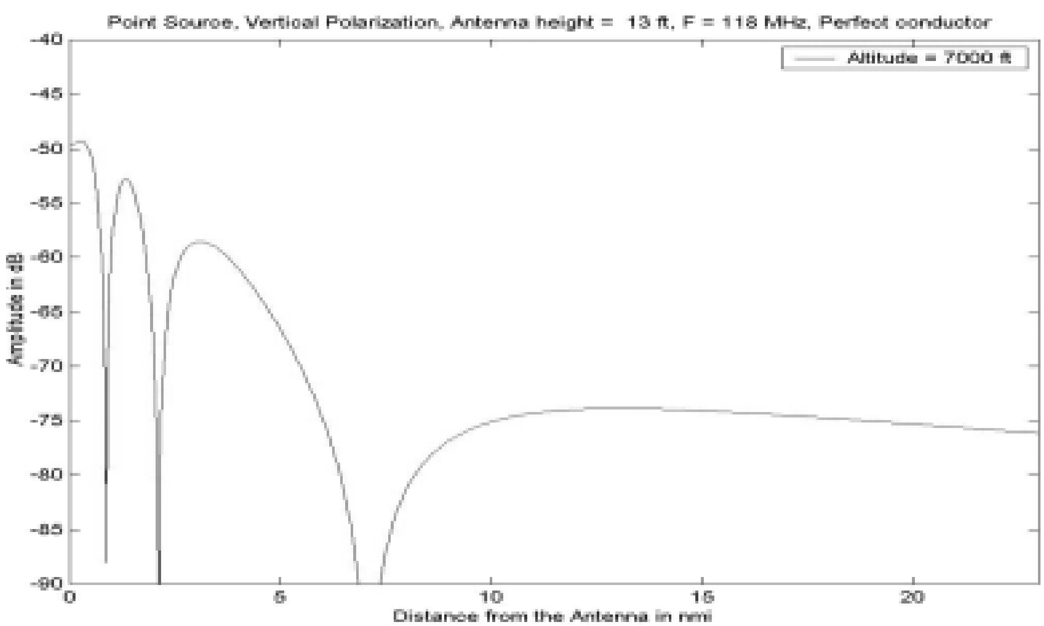


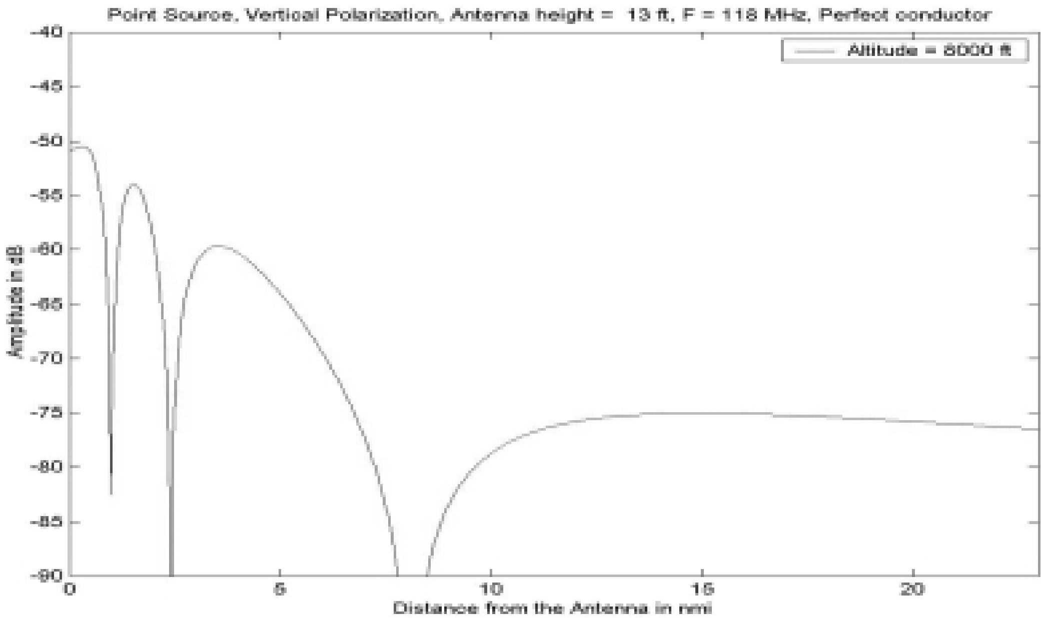
Point Source, Vertical Polarization, Antenna height = 13 ft, F = 118 MHz, Perfect conductor
Altitude = 3000 ft
Amplitude in dB
Distance from the Antenna in nmi

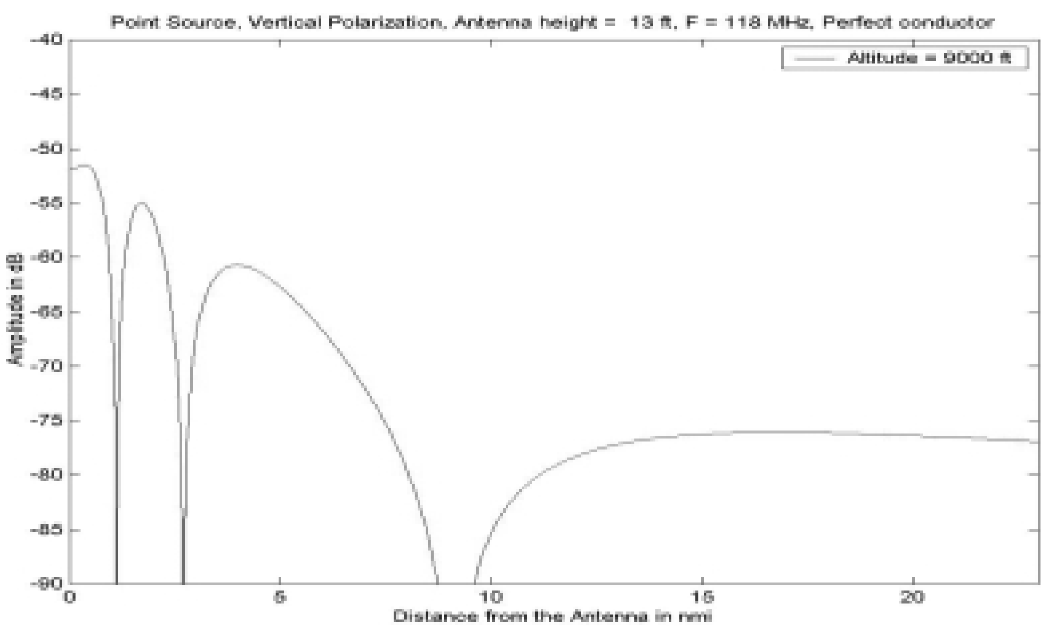

Point Source, Vertical Polarization, Antenna height = 13 ft, F = 118 MHz, Perfect conductor
Altitude = 4000 ft
Amplitude in dB
Distance from the Antenna in nmi

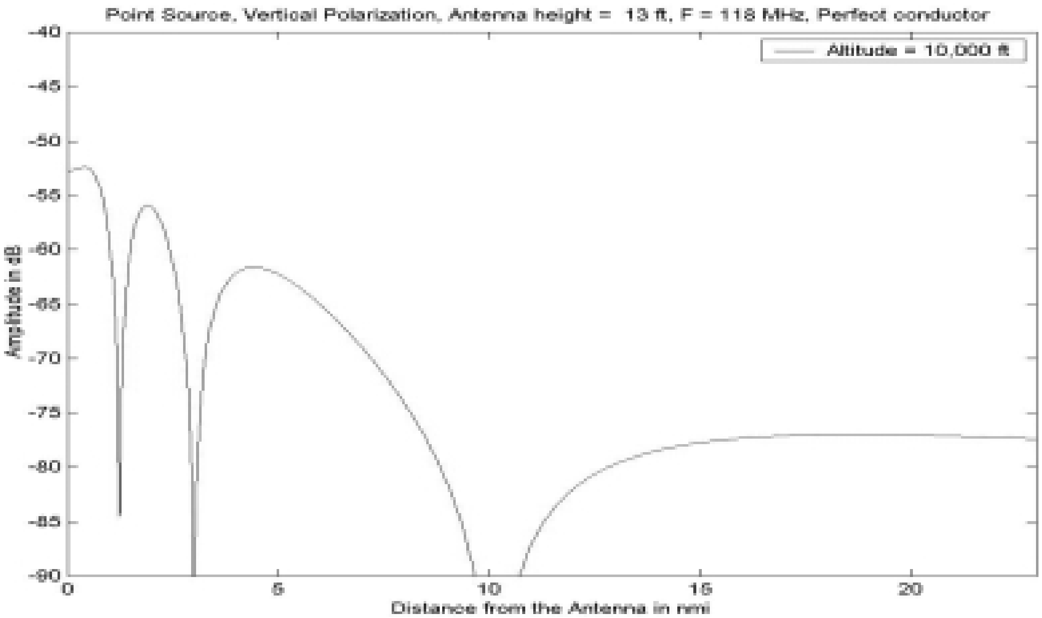

Point Source, Vertical Polarization, Antenna height = 13 ft, F = 118 MHz, Perfect conductor
Altitude = 5000 ft
Amplitude in dB
Distance from the Antenna in nmi


Point Source, Vertical Polarization, Antenna height = 13 ft, F = 118 MHz, Perfect conductor
Altitude = 6000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

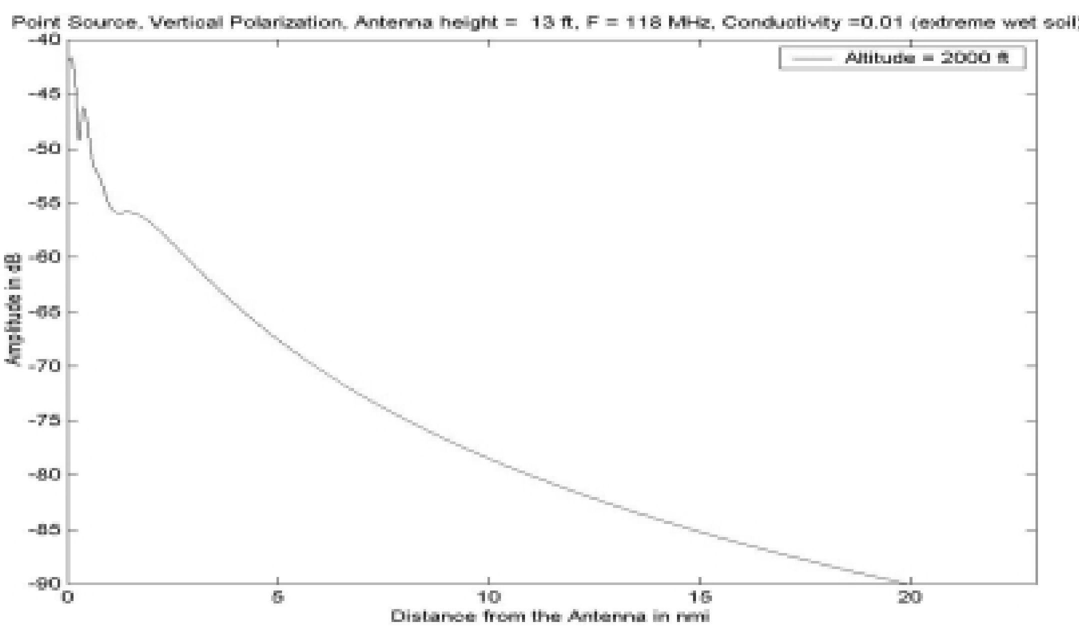

Point Source, Vertical Polarization, Antenna height = 13 ft, F = 118 MHz, Perfect conductor
Altitude = 7000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20


Point Source, Vertical Polarization, Antenna height = 13 ft, F = 118 MHz, Perfect conductor
Altitude = 8000 ft
Amplitude in dB
Distance from the Antenna in nmi

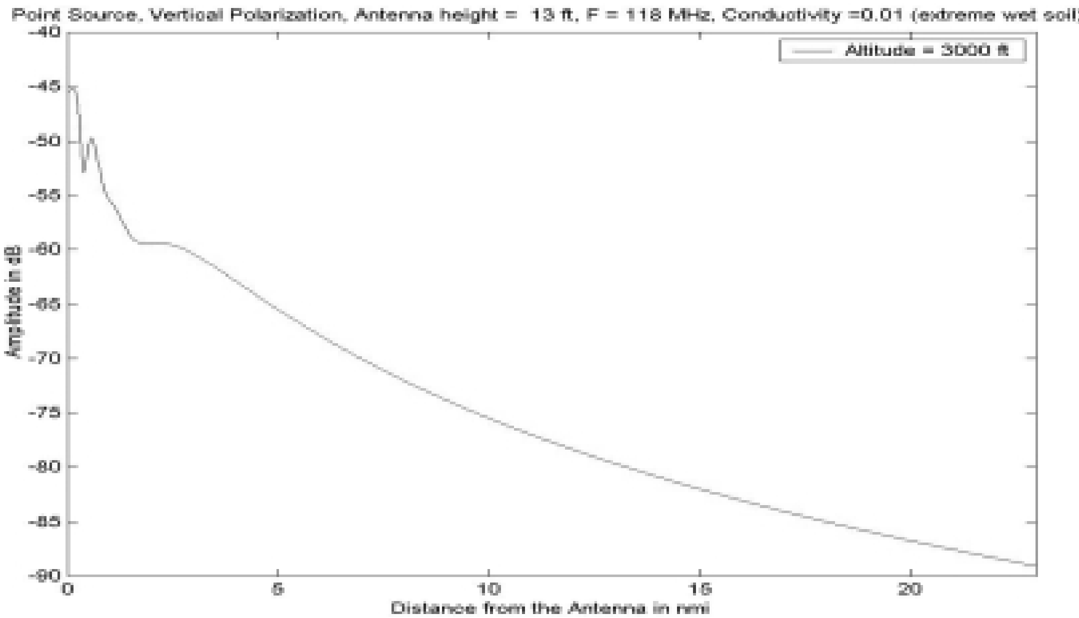

Point Source, Vertical Polarization, Antenna height = 13 ft, F = 118 MHz, Perfect conductor
Altitude = 9000 ft
Amplitude in dB
Distance from the Antenna in nmi

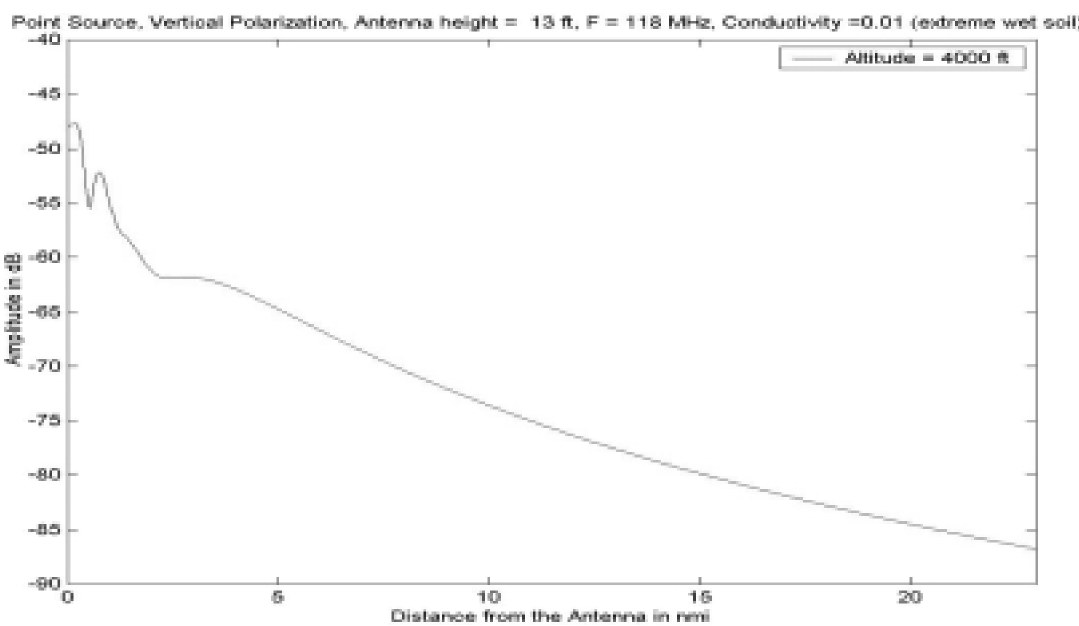


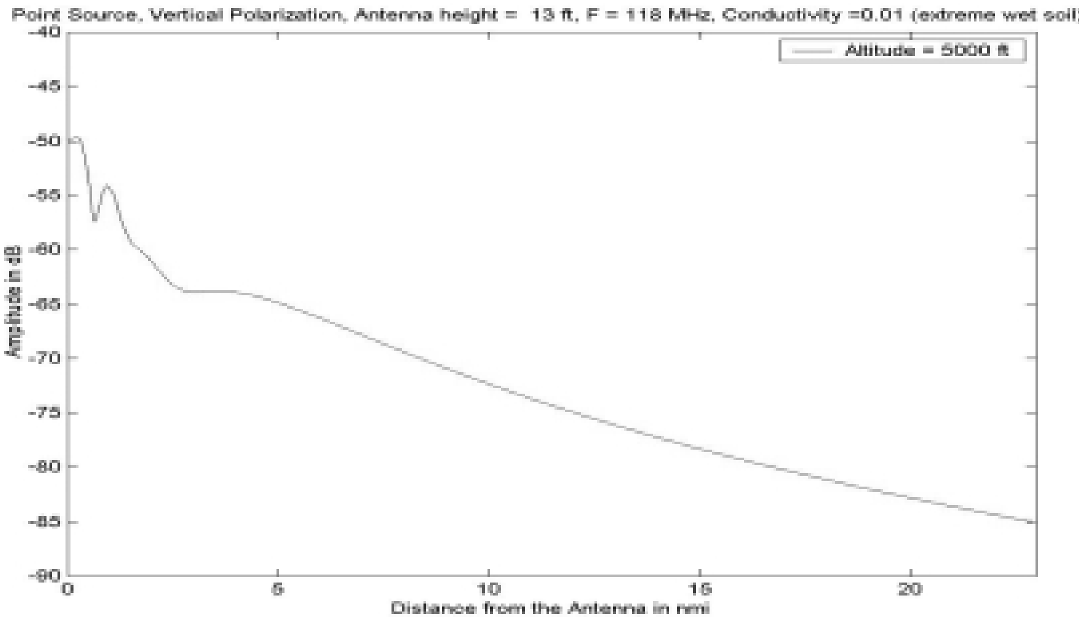
Point Source, Vertical Polarization, Antenna height = 13 ft, F = 118 MHz, Perfect conductor
Altitude = 10,000 ft
Amplitude in dB
Distance from the Antenna in nmi



Point Source, Vertical Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 2000 ft
Amplitude in dB
Distance from the Antenna in nmi


Point Source, Vertical Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 3000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20


Point Source, Vertical Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 4000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20


Point Source, Vertical Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 5000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
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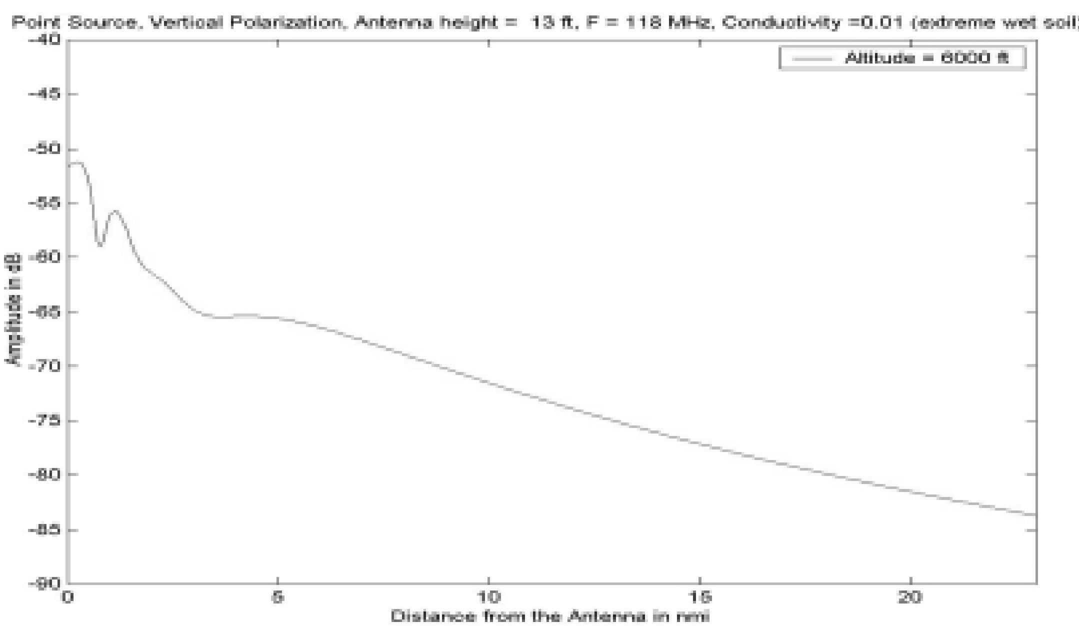
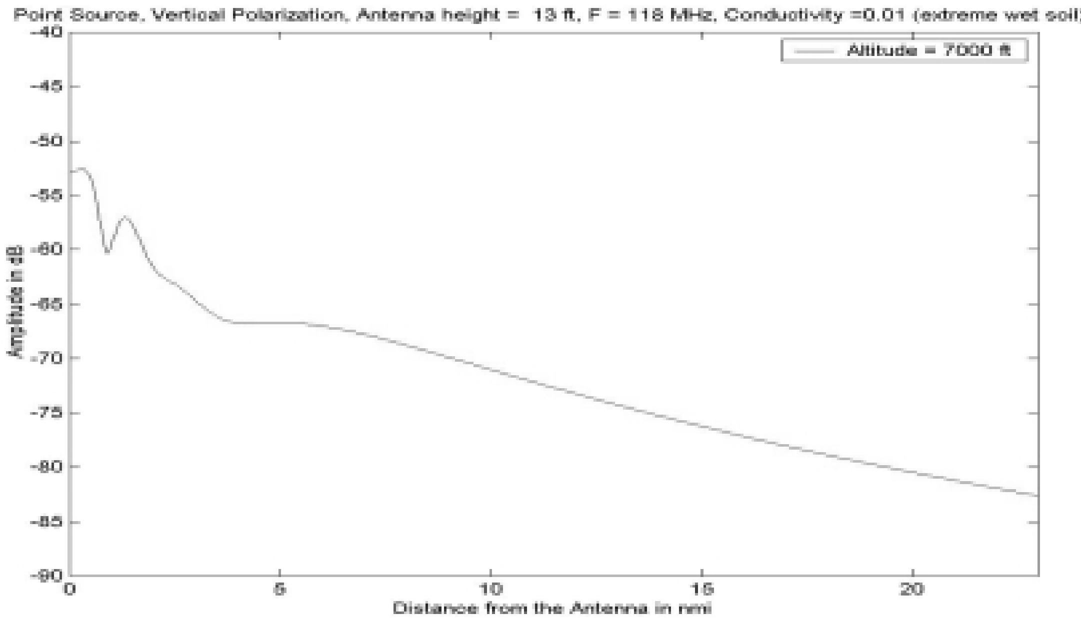
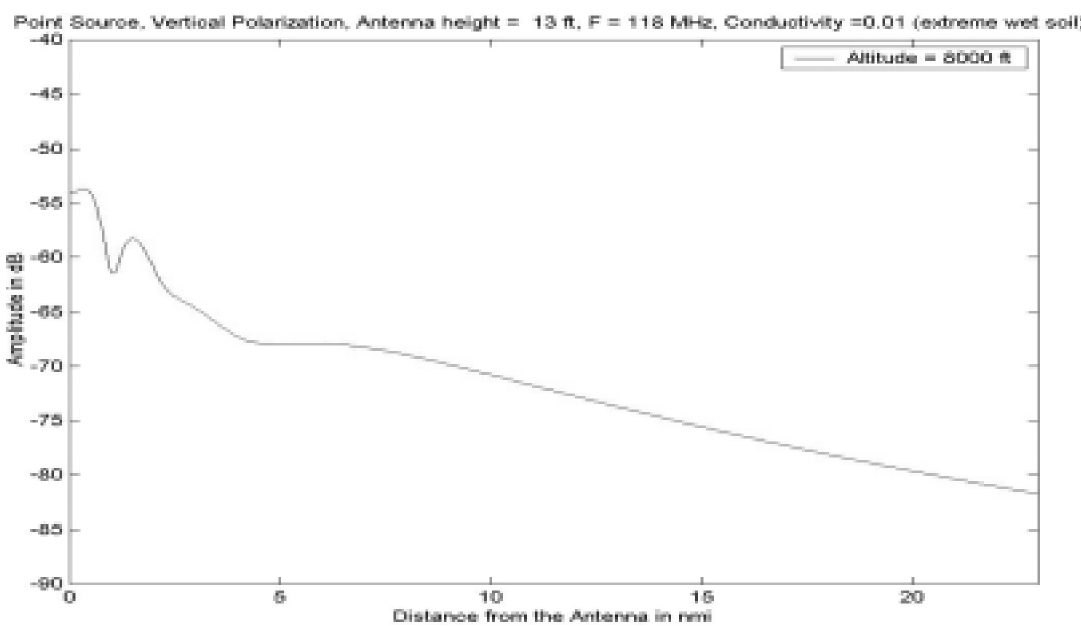
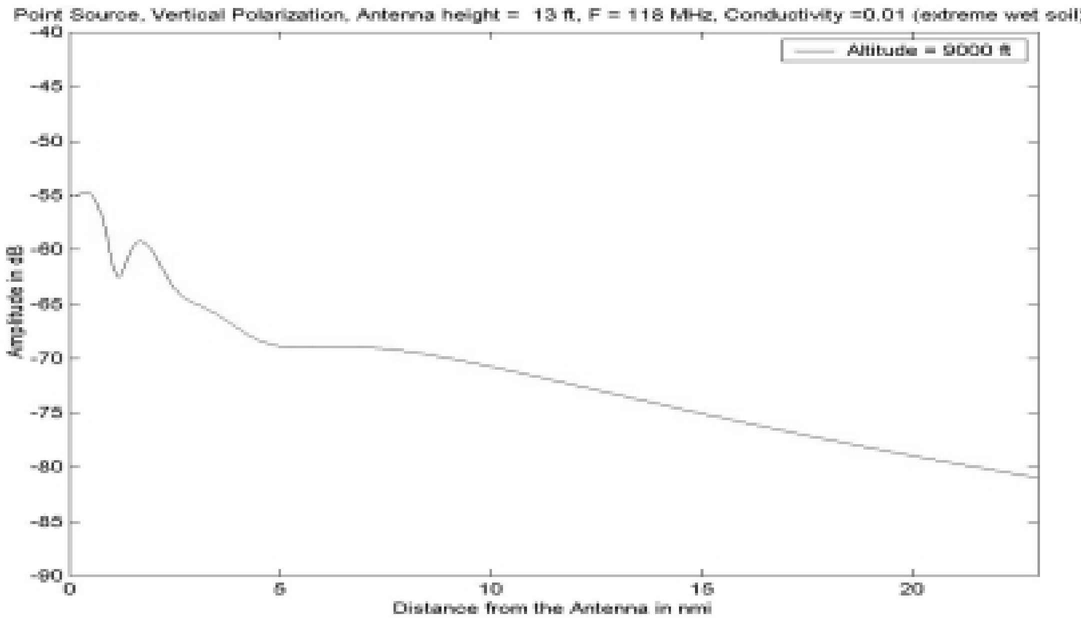
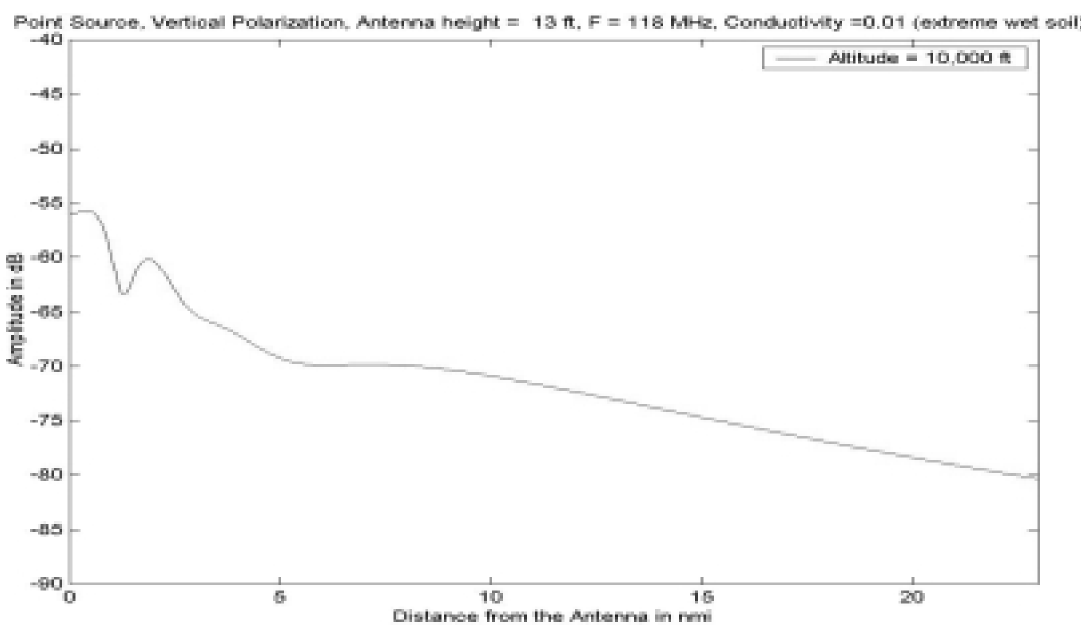
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

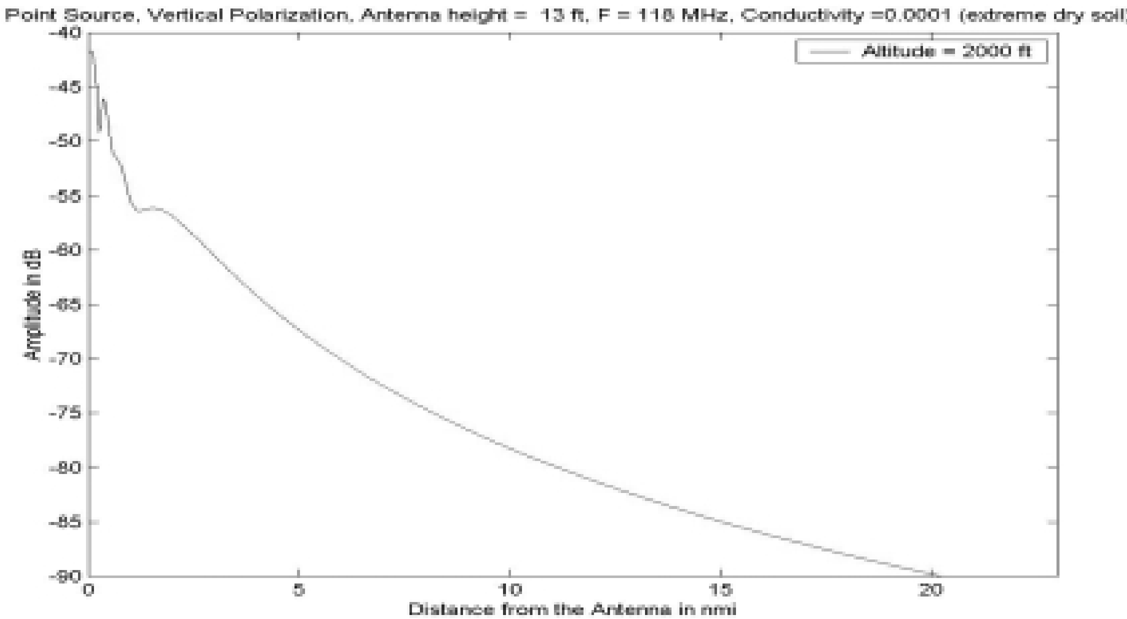

Point Source, Vertical Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 6000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

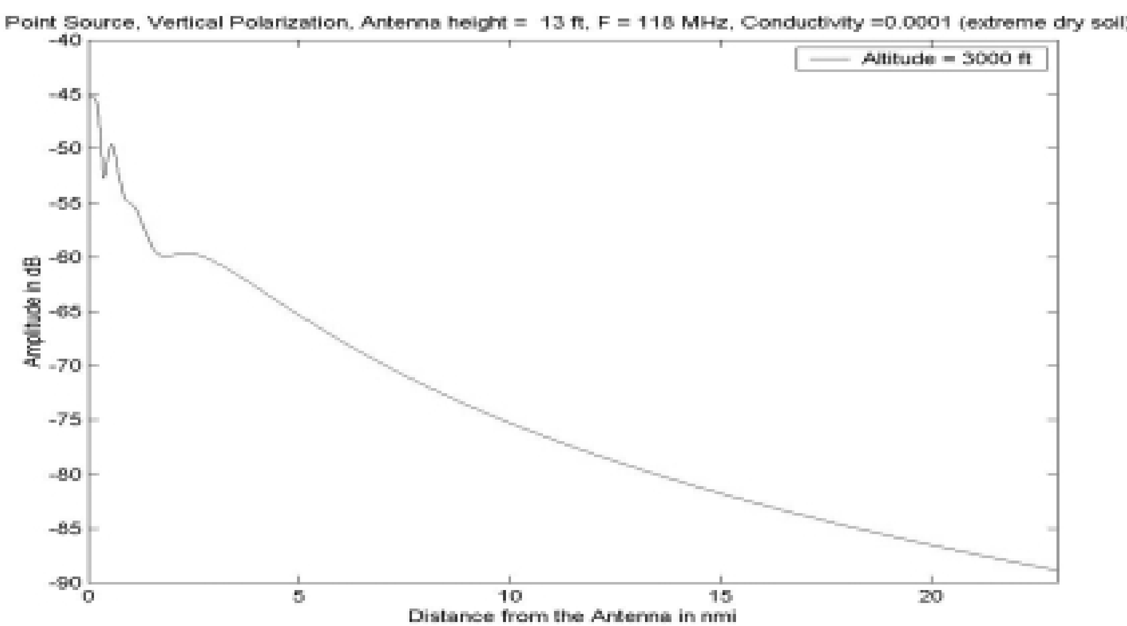

Point Source, Vertical Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 7000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

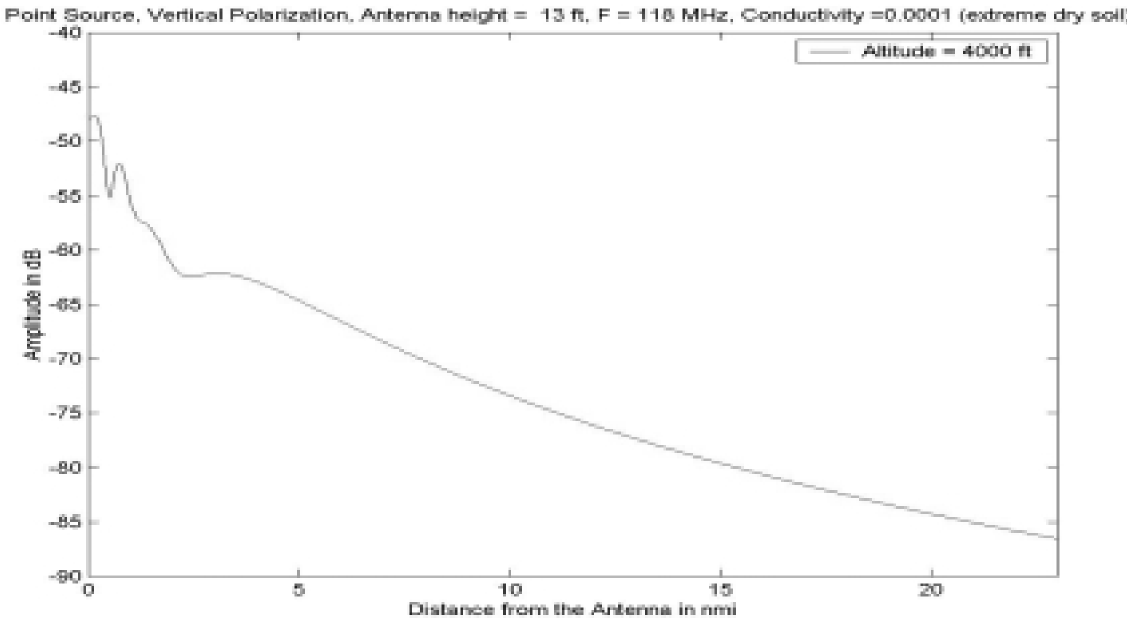

Point Source, Vertical Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 8000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

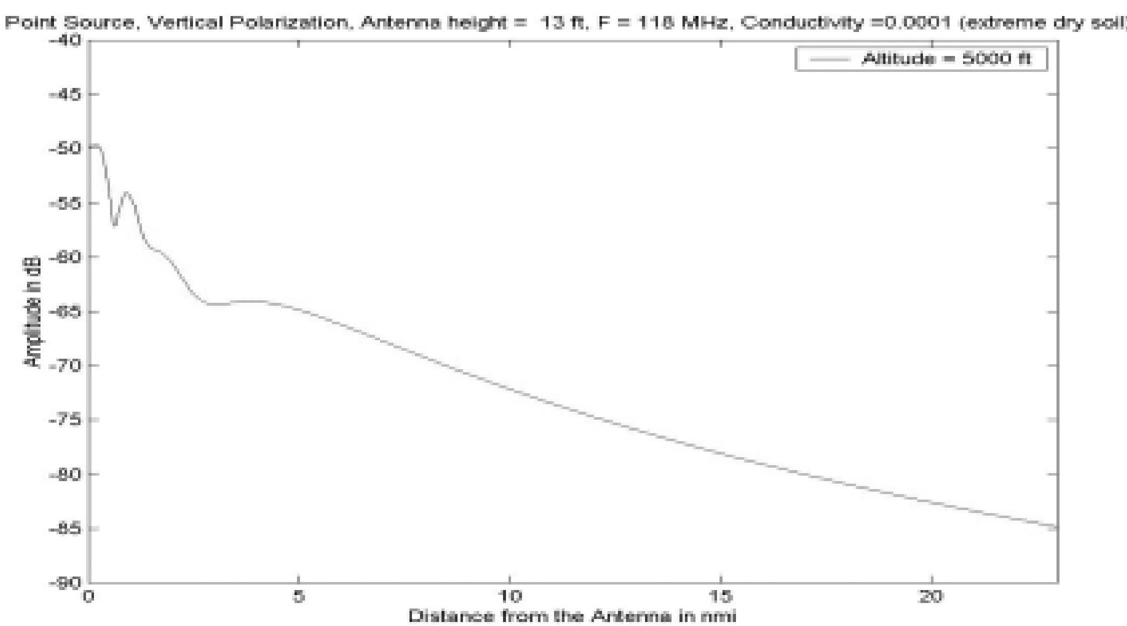

Point Source, Vertical Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 9000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

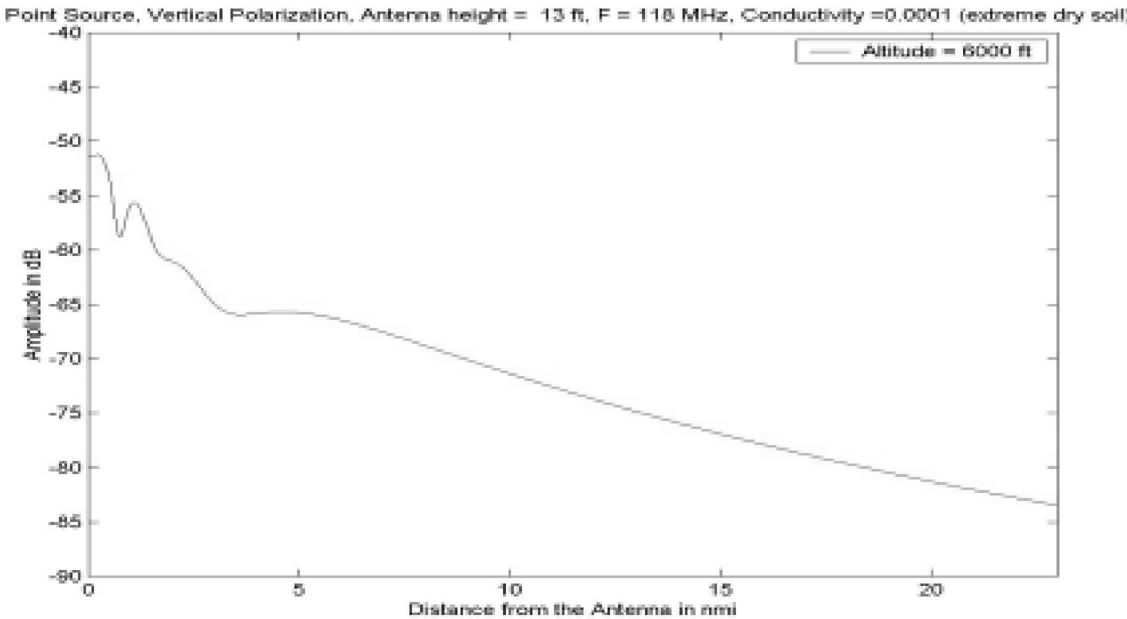

Point Source, Vertical Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 10,000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

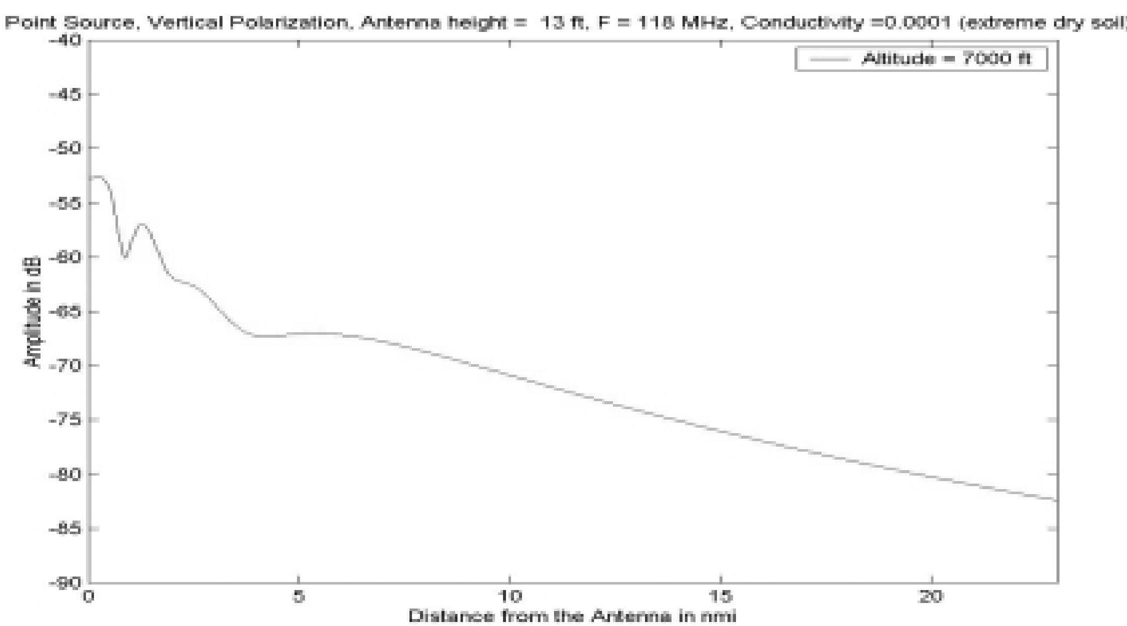

Point Source, Vertical Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 2000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

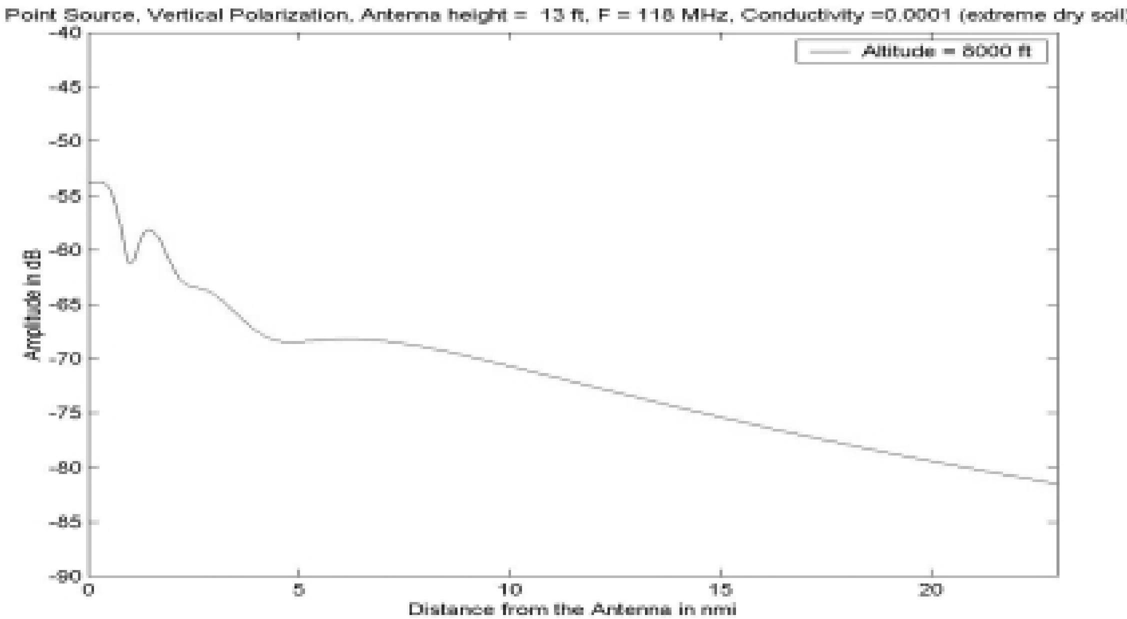

Point Source, Vertical Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 3000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

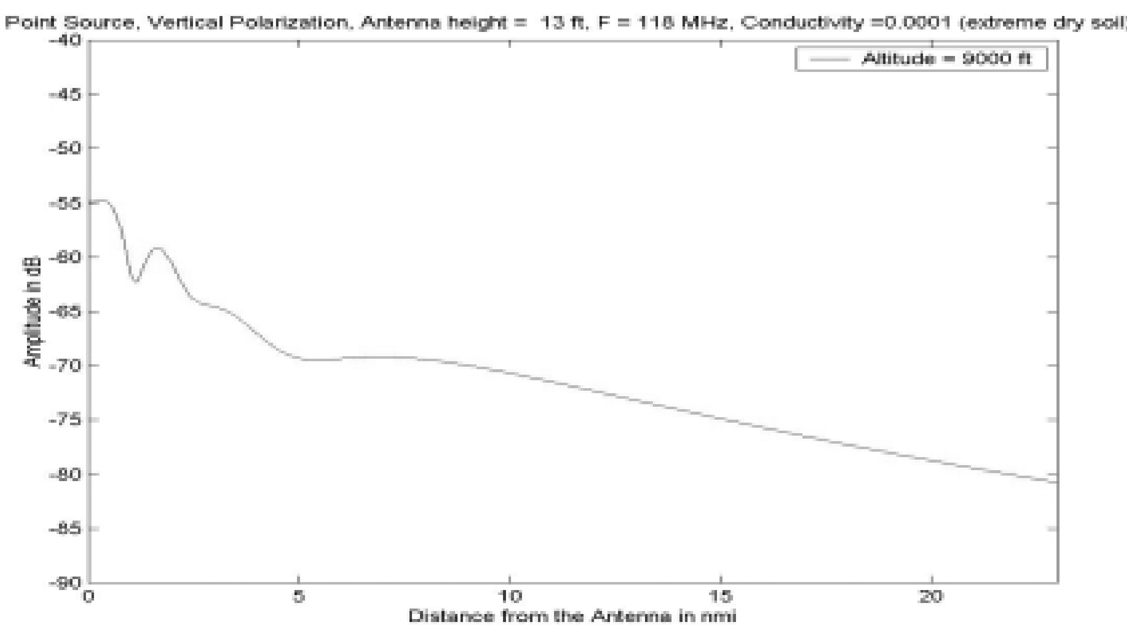

Point Source, Vertical Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 4000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

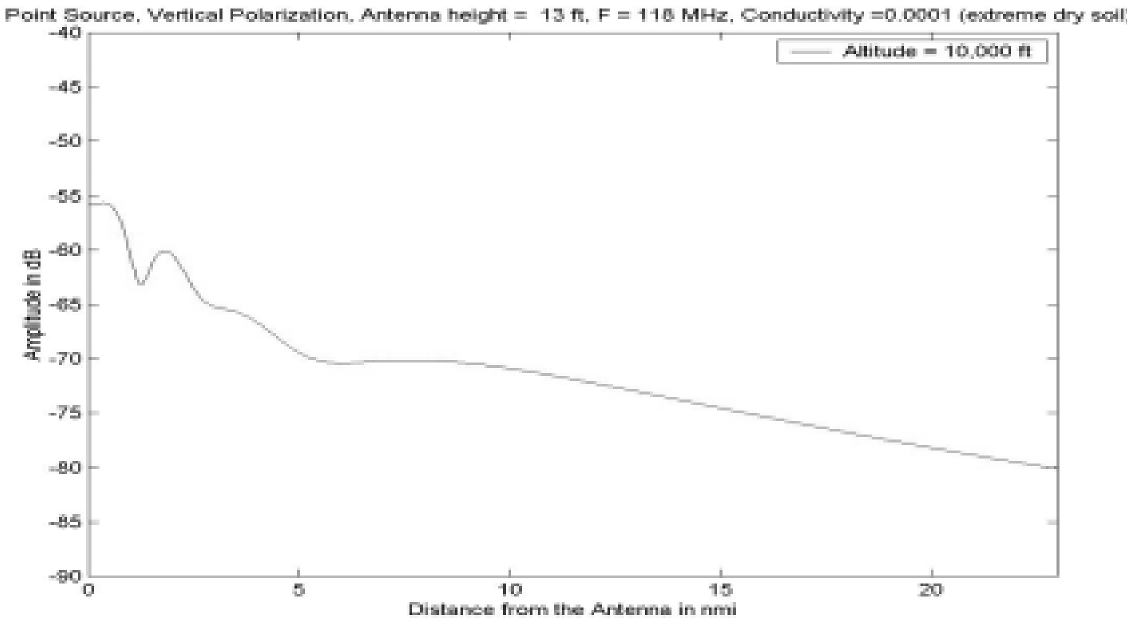

Point Source, Vertical Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 5000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

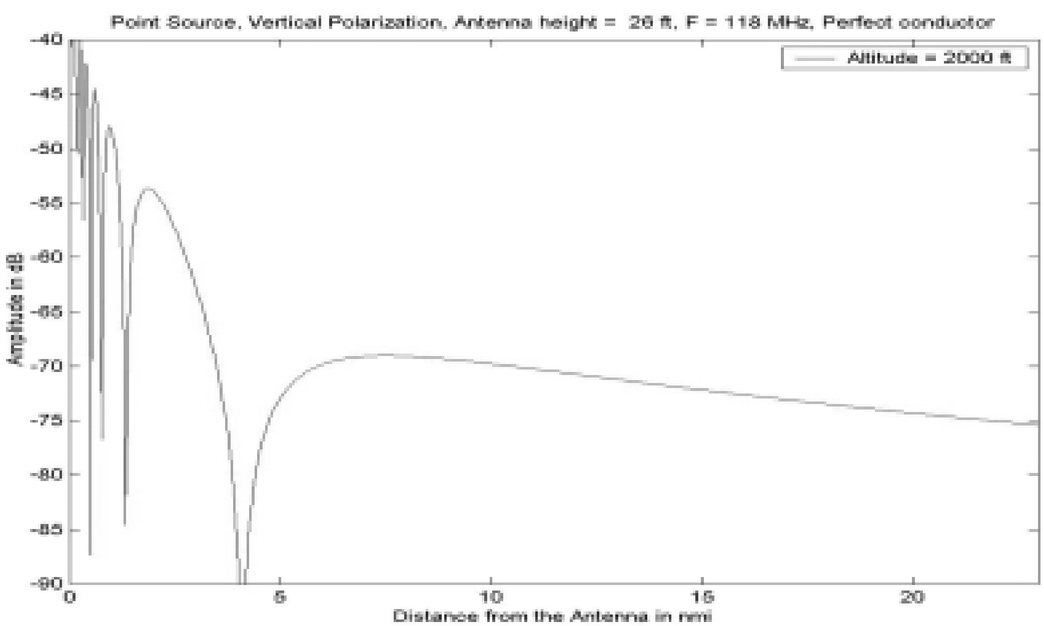

Point Source, Vertical Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 6000 ft
Amplitude in dB
Distance from the Antenna in nmi

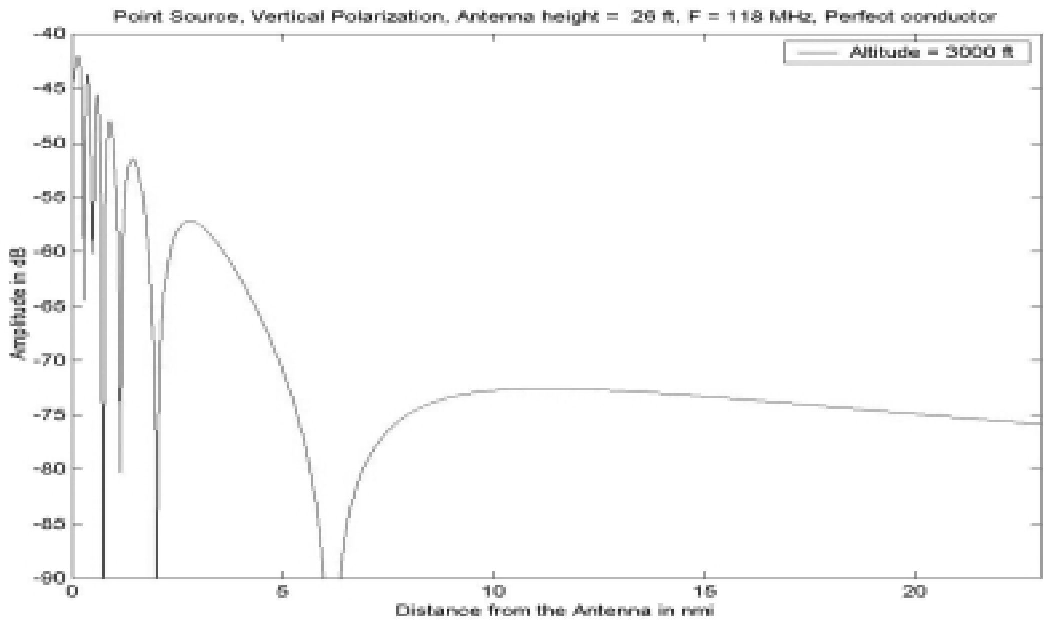

Point Source, Vertical Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 7000 ft
Amplitude in dB
Distance from the Antenna in nmi

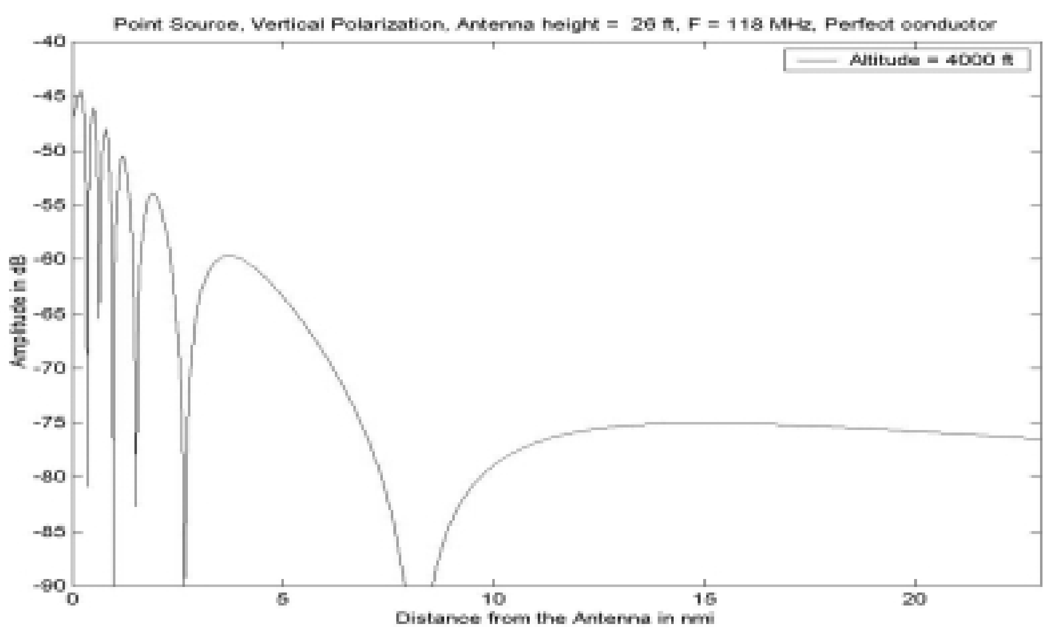

Point Source, Vertical Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 8000 ft
Amplitude in dB
Distance from the Antenna in nmi

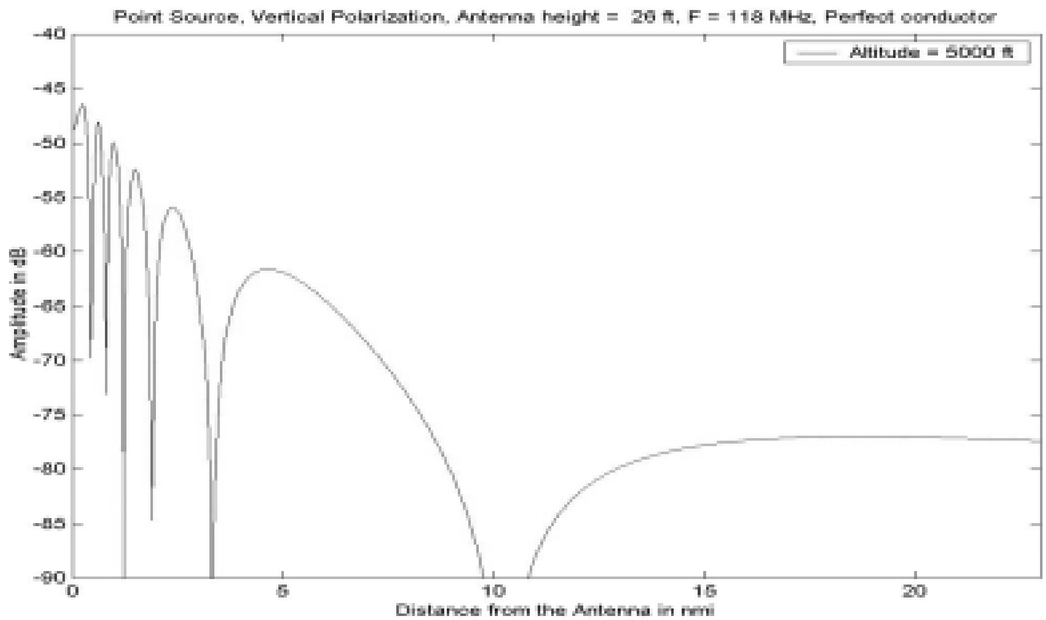

Point Source, Vertical Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 9000 ft
Amplitude in dB
Distance from the Antenna in nmi

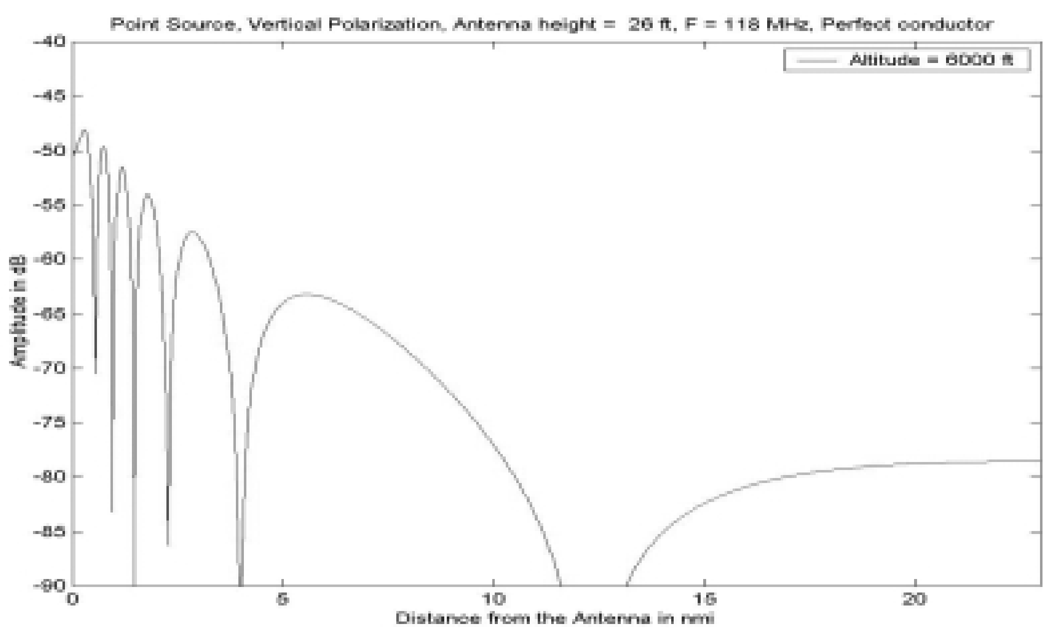

Point Source, Vertical Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 10,000 ft
Amplitude in dB
Distance from the Antenna in nmi

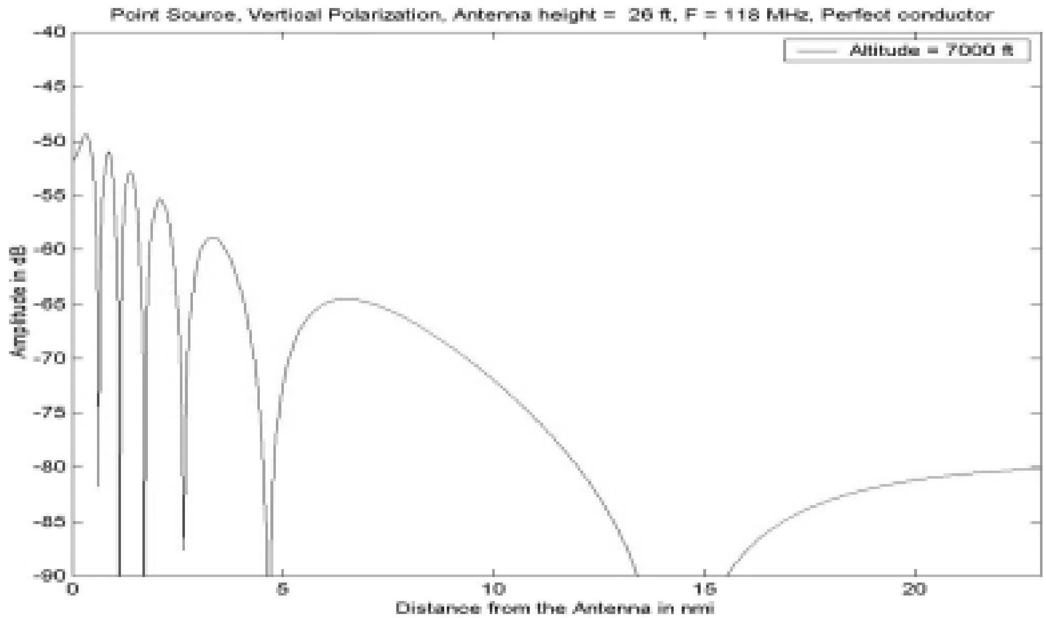

Point Source, Vertical Polarization, Antenna height = 26 ft, F = 118 MHz, Perfect conductor
Altitude = 2000 ft
Amplitude in dB
Distance from the Antenna in nmi


Point Source, Vertical Polarization, Antenna height = 26 ft, F = 118 MHz, Perfect conductor
Altitude = 3000 ft
Amplitude in dB
Distance from the Antenna in nmi

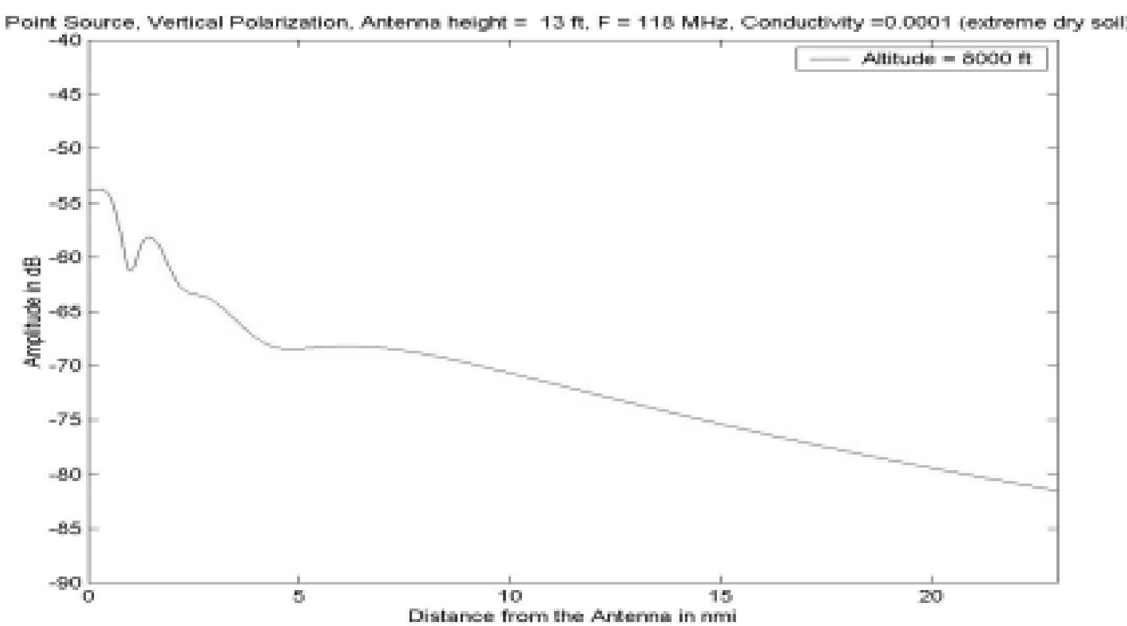

Point Source, Vertical Polarization, Antenna height = 26 ft, F = 118 MHz, Perfect conductor
Altitude = 4000 ft
Amplitude in dB
Distance from the Antenna in nmi


Point Source, Vertical Polarization, Antenna height = 26 ft, F = 118 MHz, Perfect conductor
Altitude = 5000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

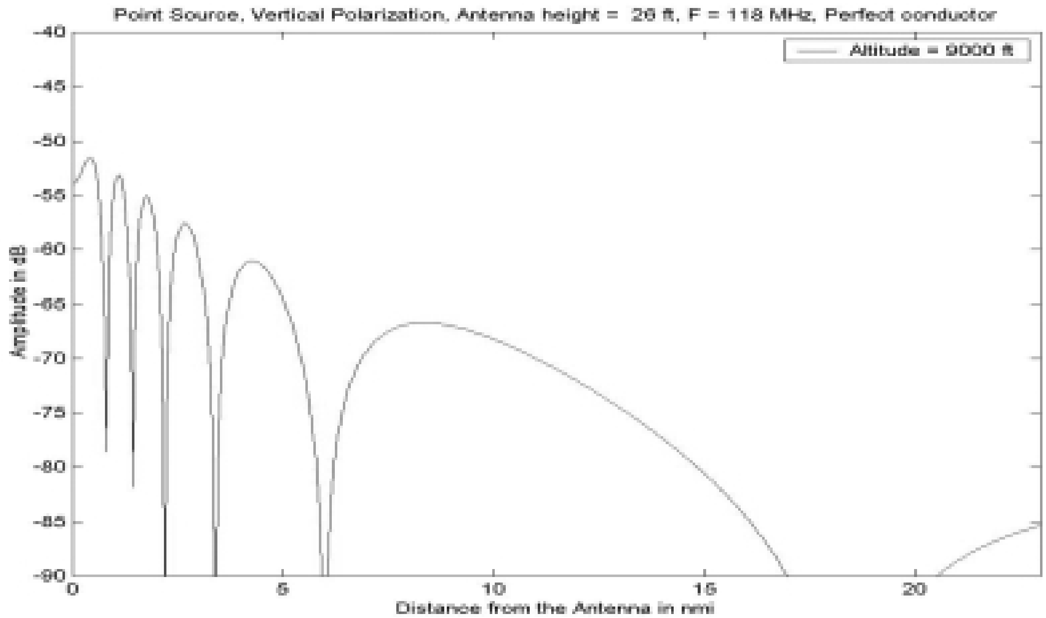

Point Source, Vertical Polarization, Antenna height = 26 ft, F = 118 MHz, Perfect conductor
Altitude = 6000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

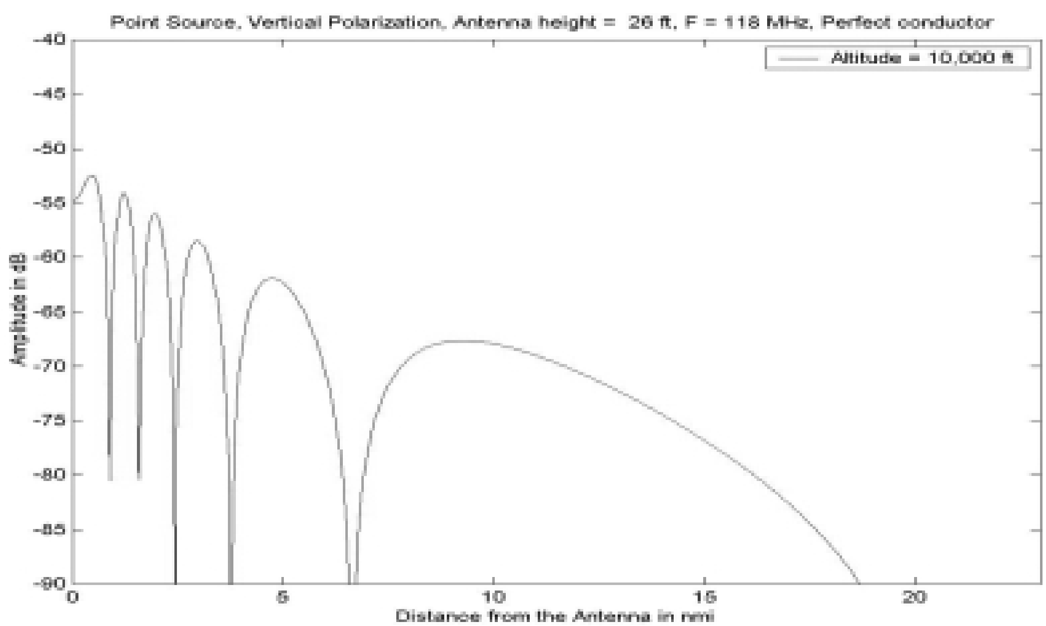


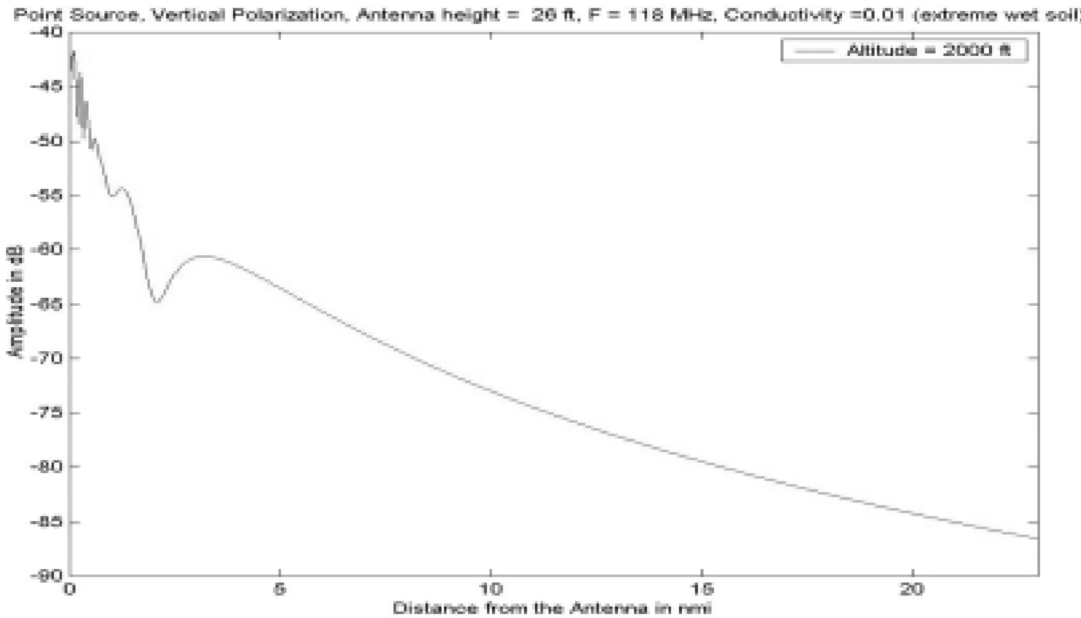
Point Source, Vertical Polarization, Antenna height = 26 ft, F = 118 MHz, Perfect conductor
Altitude = 7000 ft
Amplitude in dB
Distance from the Antenna in nmi

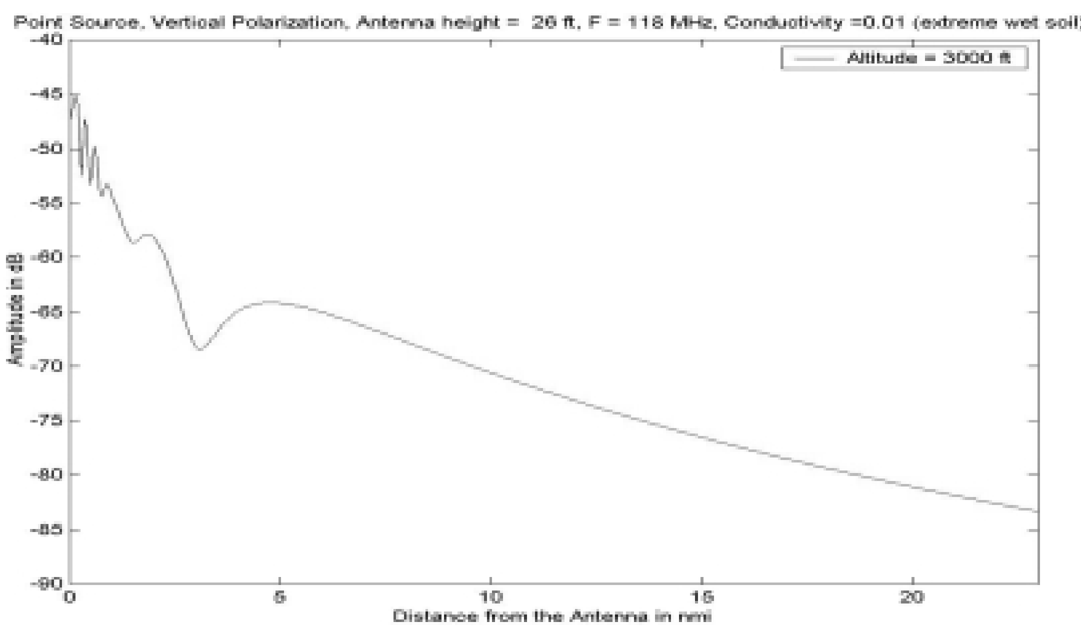


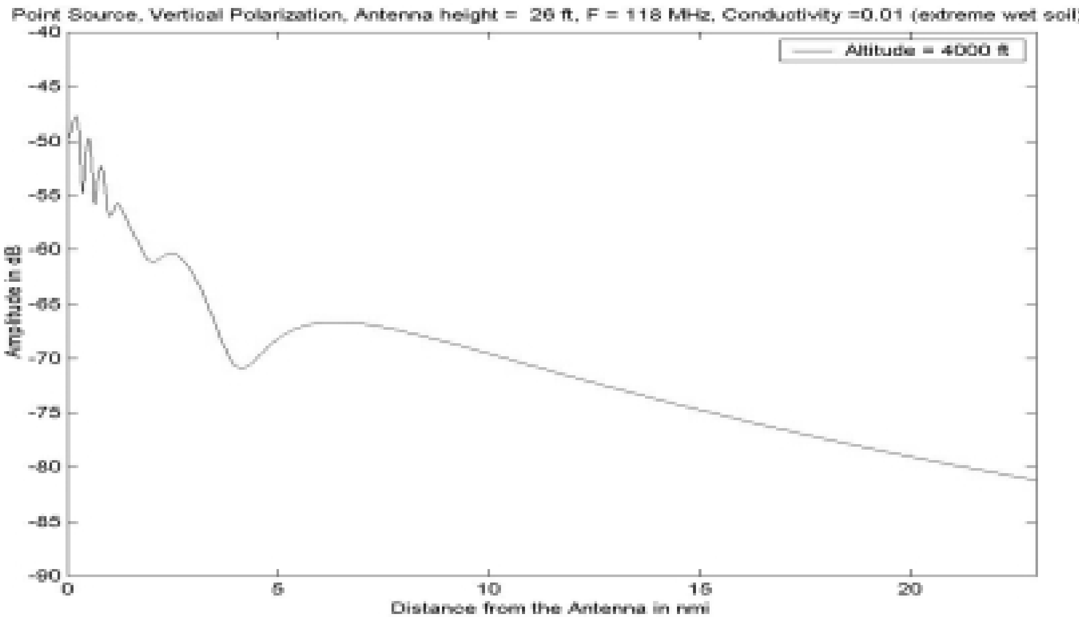
Point Source, Vertical Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 8000 ft
Amplitude in dB
Distance from the Antenna in nmi


Point Source, Vertical Polarization, Antenna height = 26 ft, F = 118 MHz, Perfect conductor
Altitude = 9000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

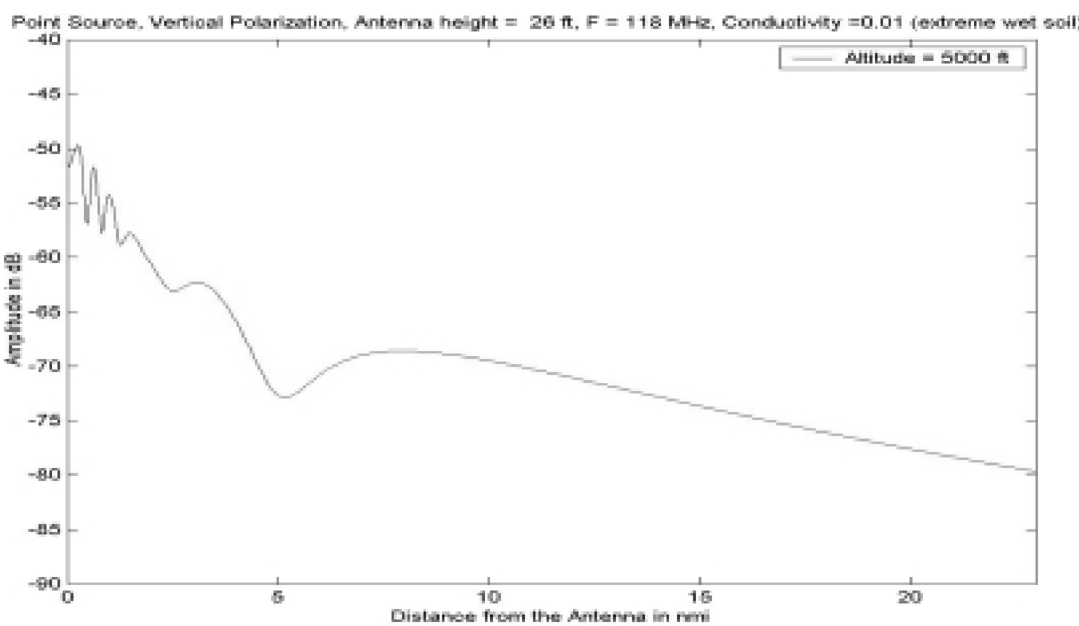

Point Source, Vertical Polarization, Antenna height = 26 ft, F = 118 MHz, Perfect conductor
Altitude = 10,000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20


Point Source, Vertical Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 2000 ft
Amplitude in dB
Distance from the Antenna in nmi

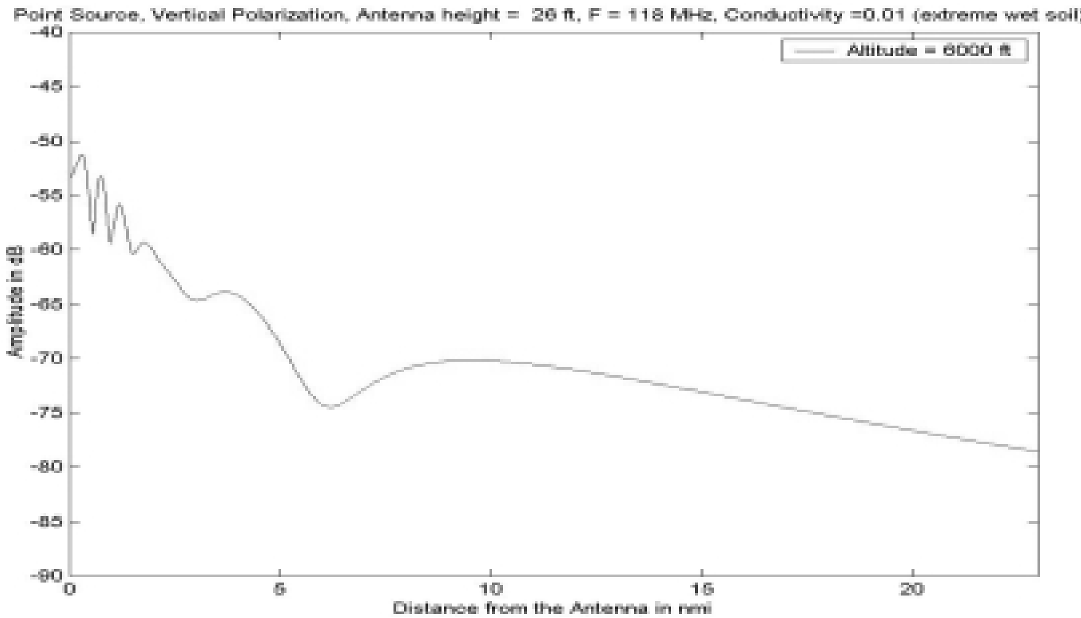

Point Source, Vertical Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 3000 ft
Amplitude in dB
Distance from the Antenna in nmi

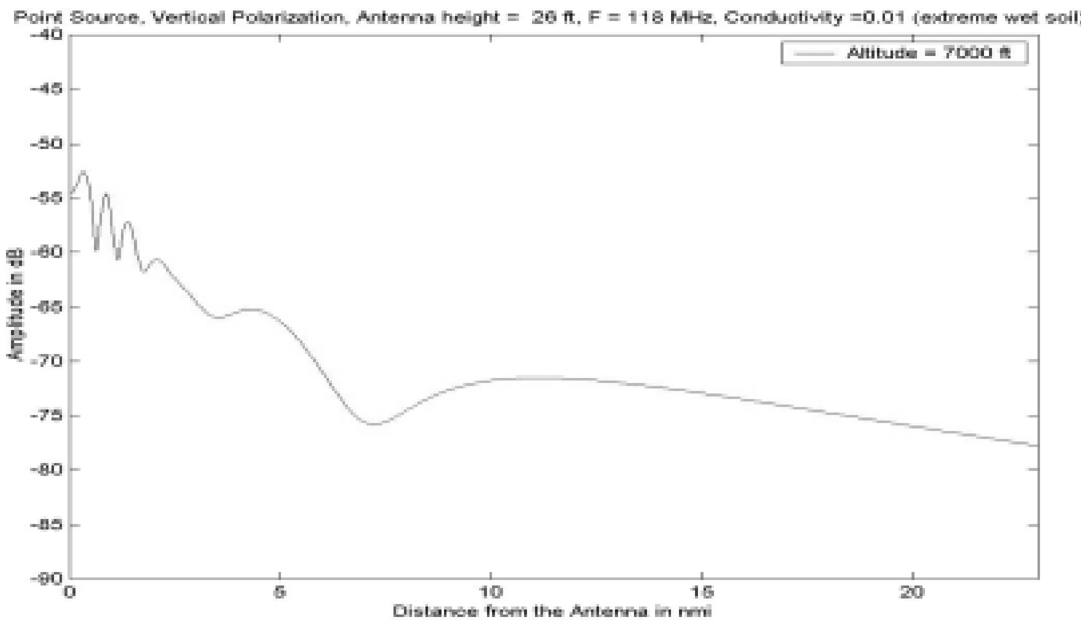


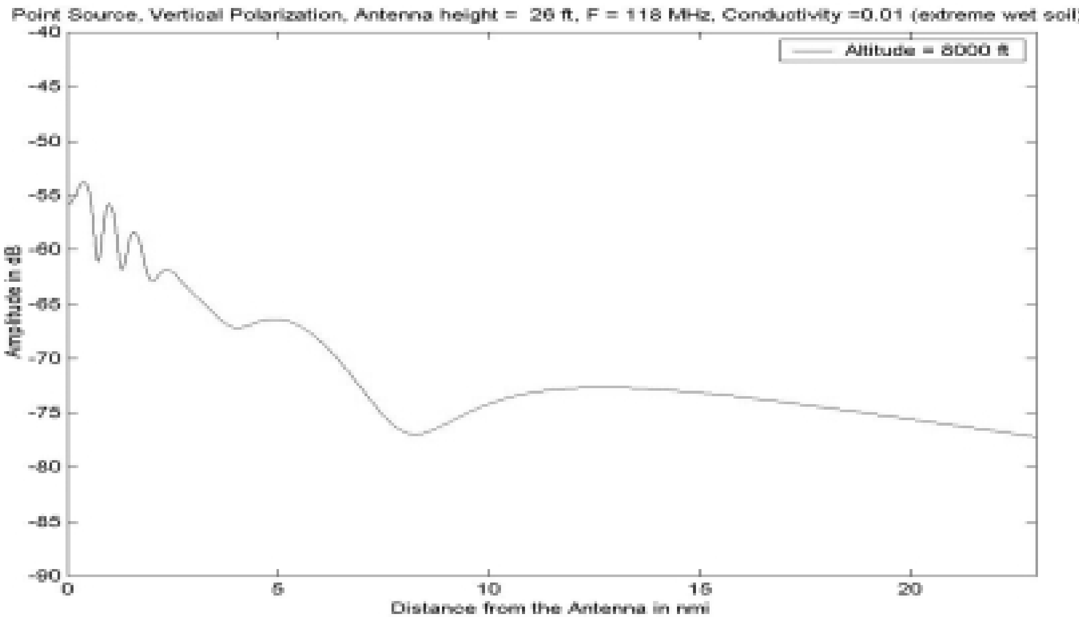
Point Source, Vertical Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 4000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20



Point Source, Vertical Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 5000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20


Point Source, Vertical Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 6000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20


Point Source, Vertical Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 7000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20


Point Source, Vertical Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 8000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
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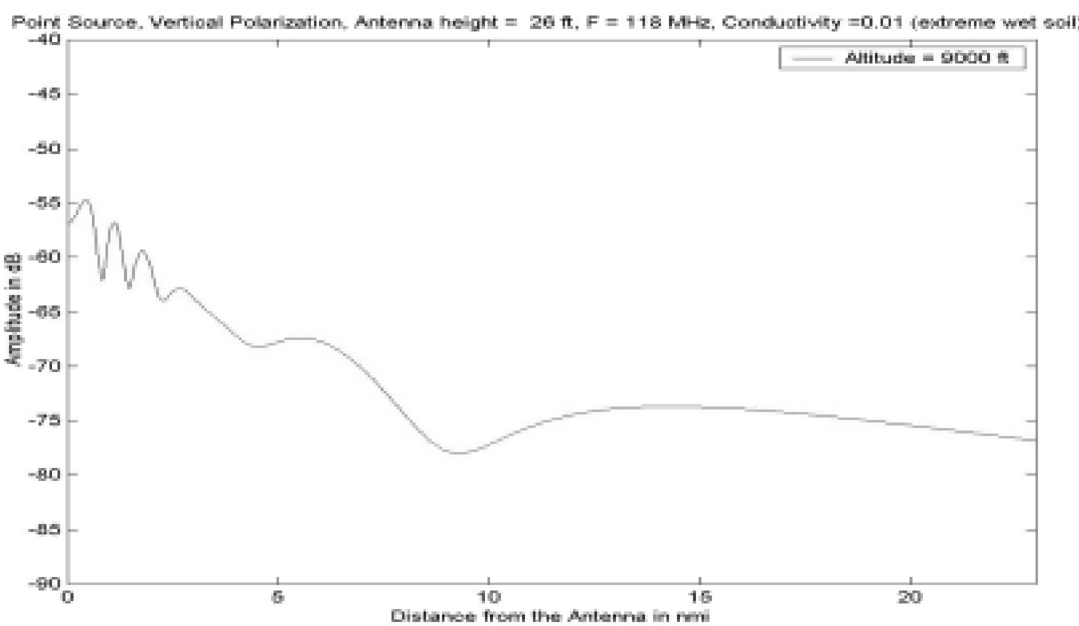
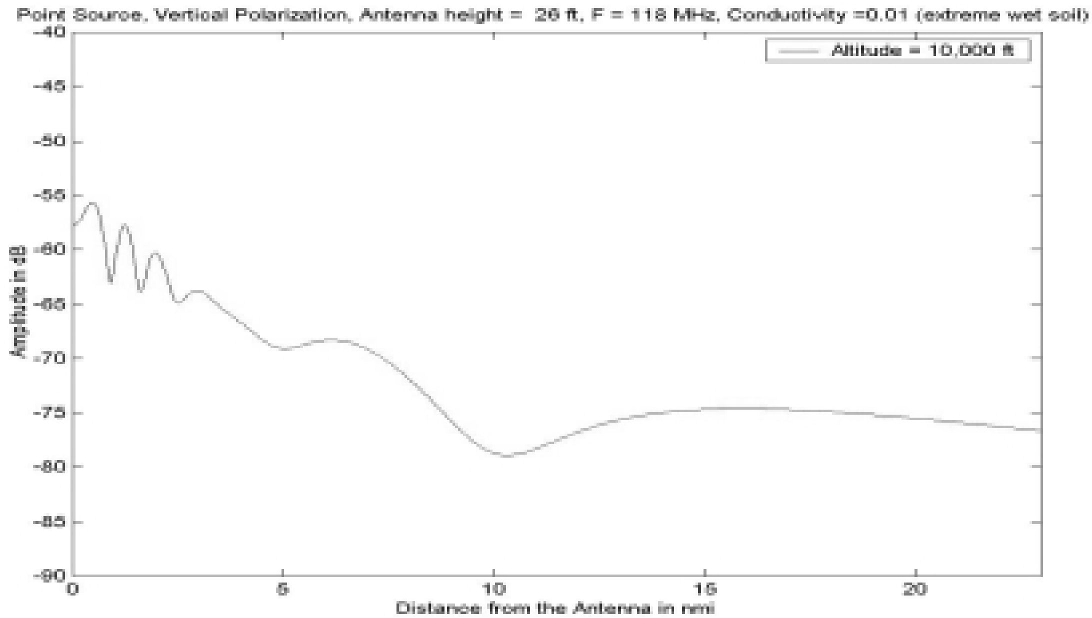
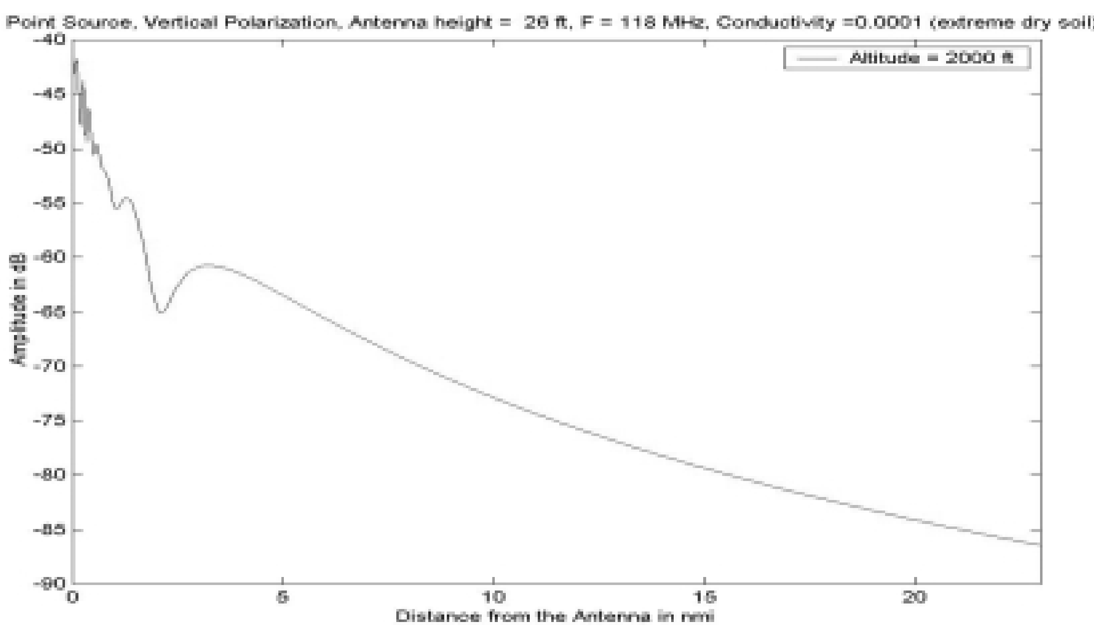
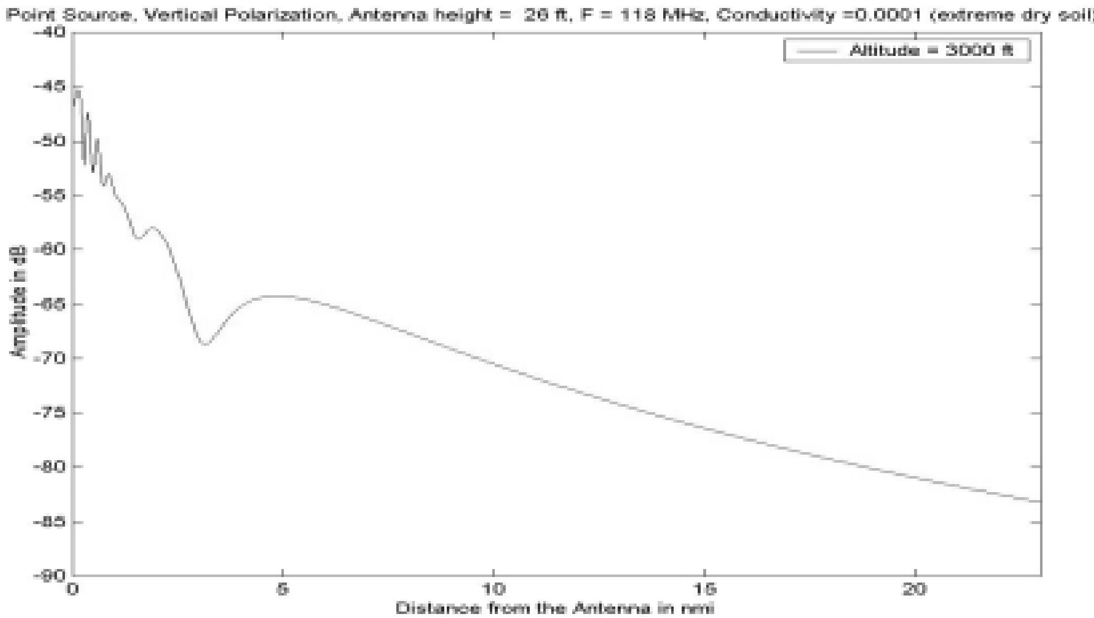
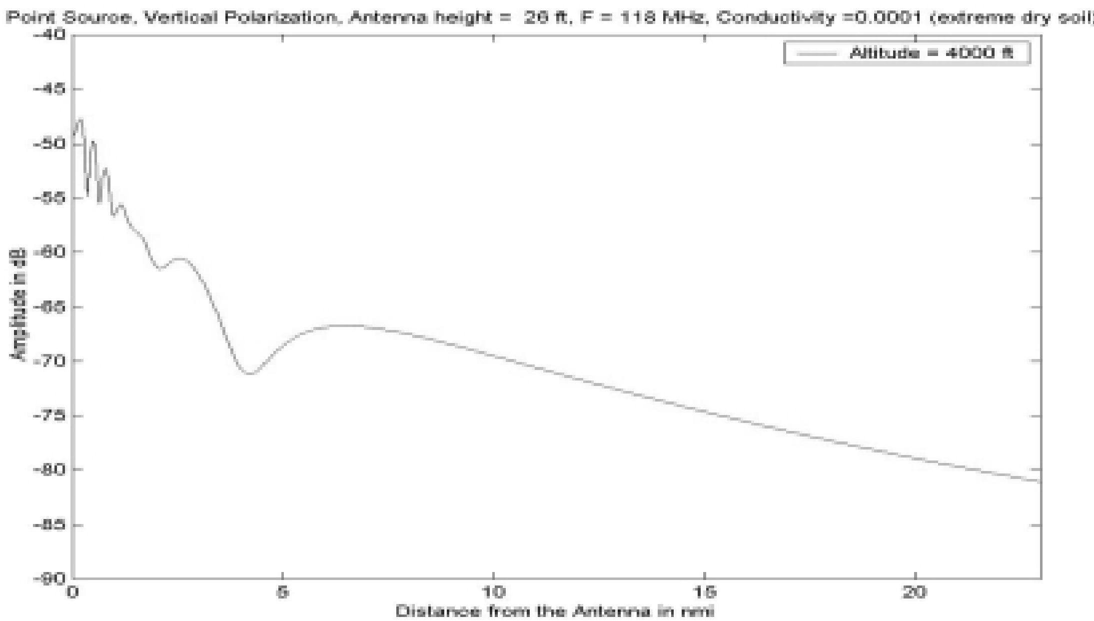
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

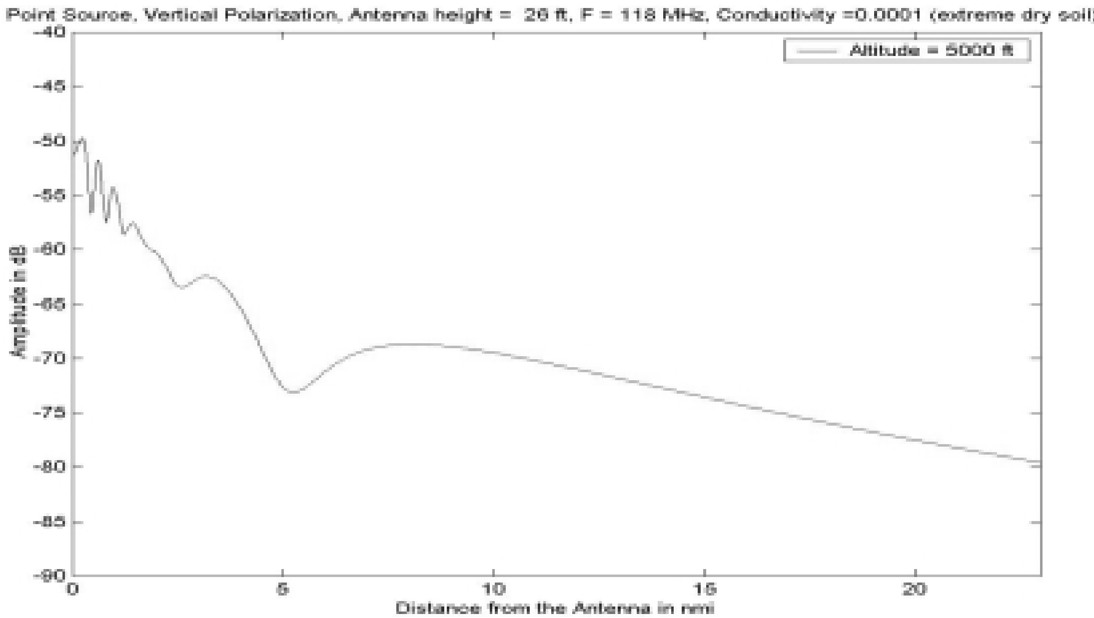

Point Source, Vertical Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 9000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

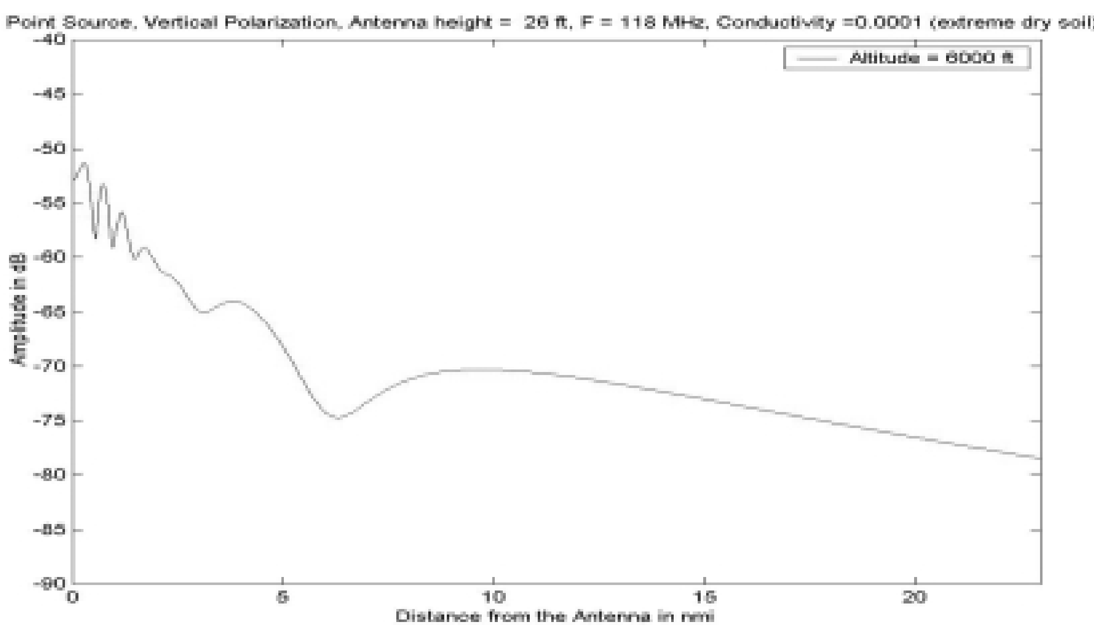

Point Source, Vertical Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 10,000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

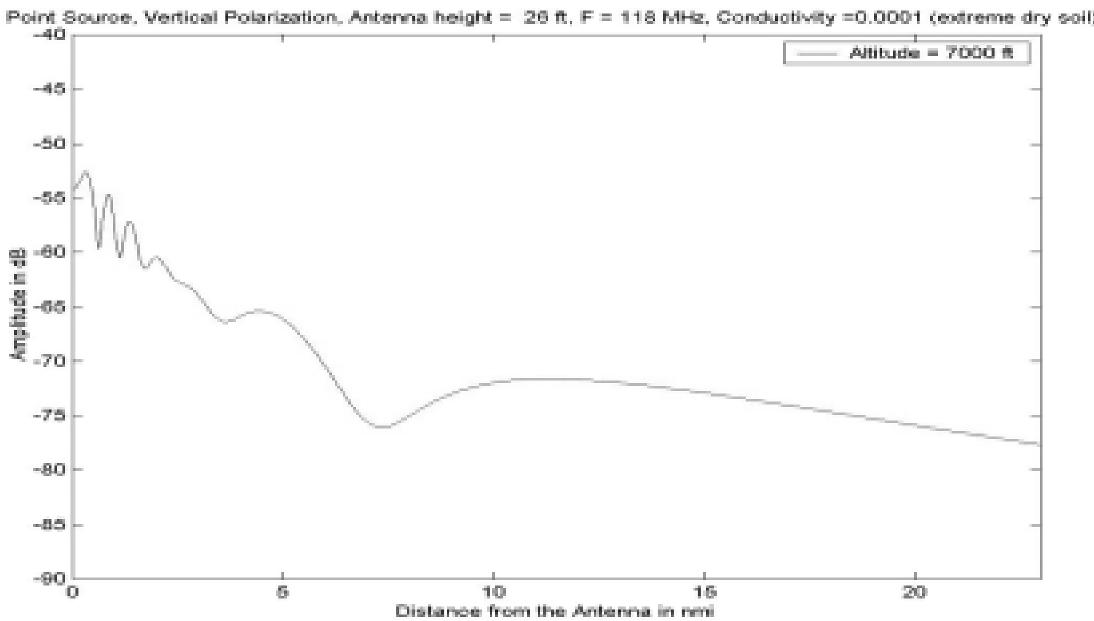

Point Source, Vertical Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 2000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

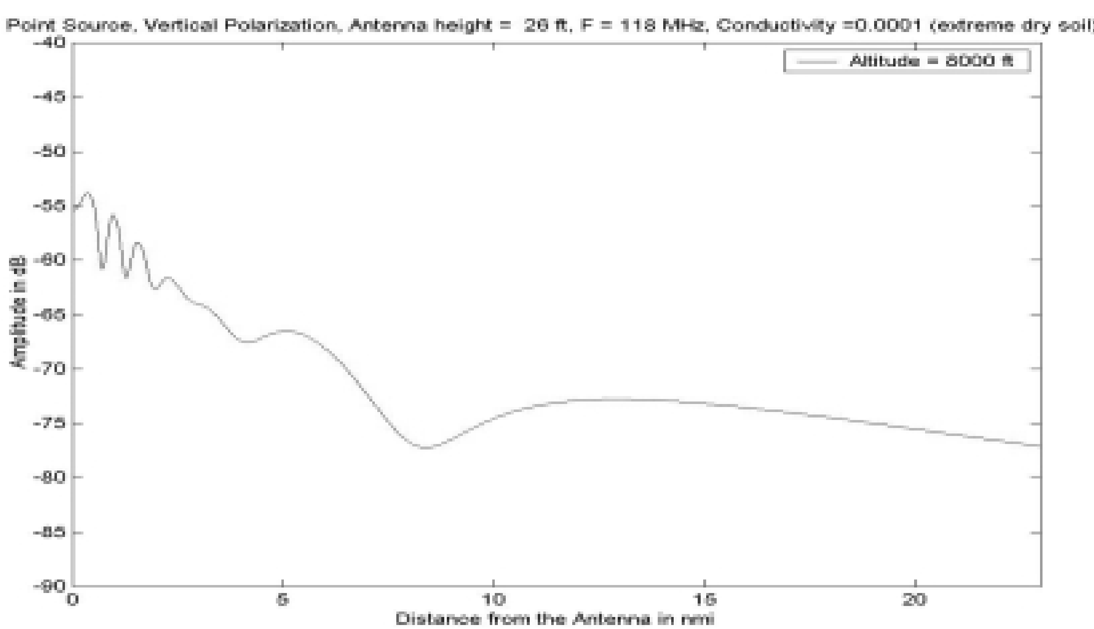

Point Source, Vertical Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 3000 ft
Amplitude in dB
Distance from the Antenna in nmi

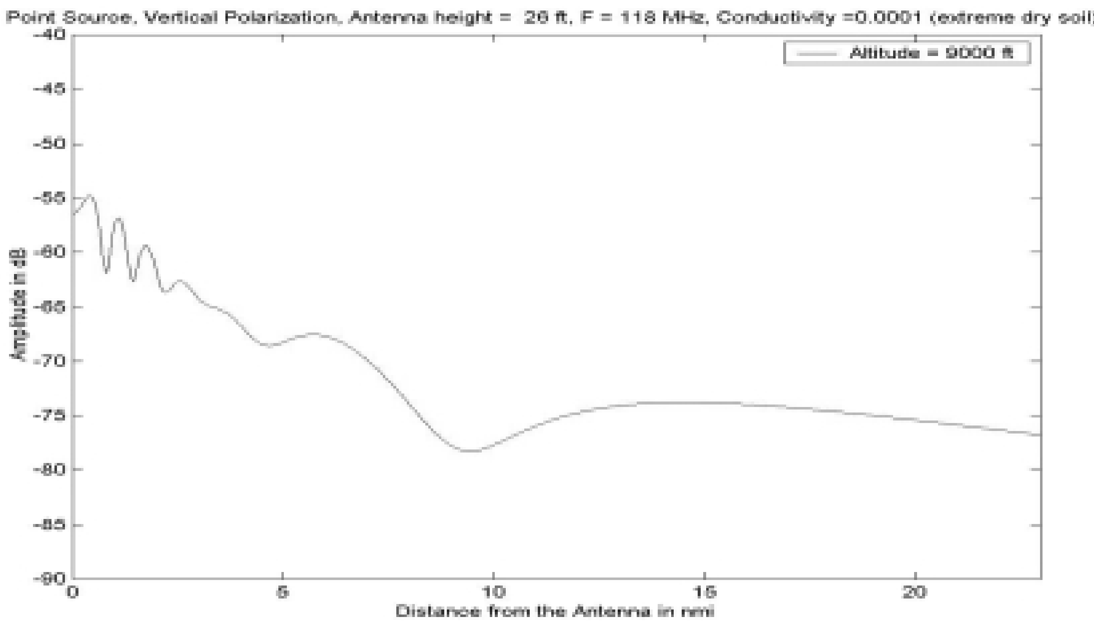

Point Source, Vertical Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 4000 ft
Amplitude in dB
Distance from the Antenna in nmi

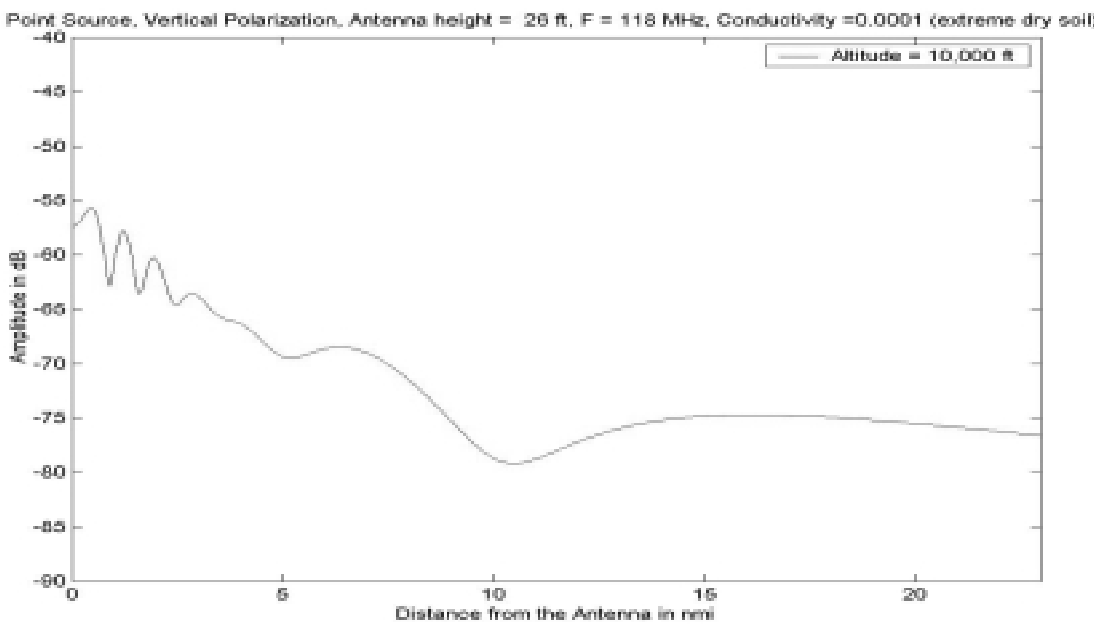

Point Source, Vertical Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 5000 ft
Amplitude in dB
Distance from the Antenna in nmi

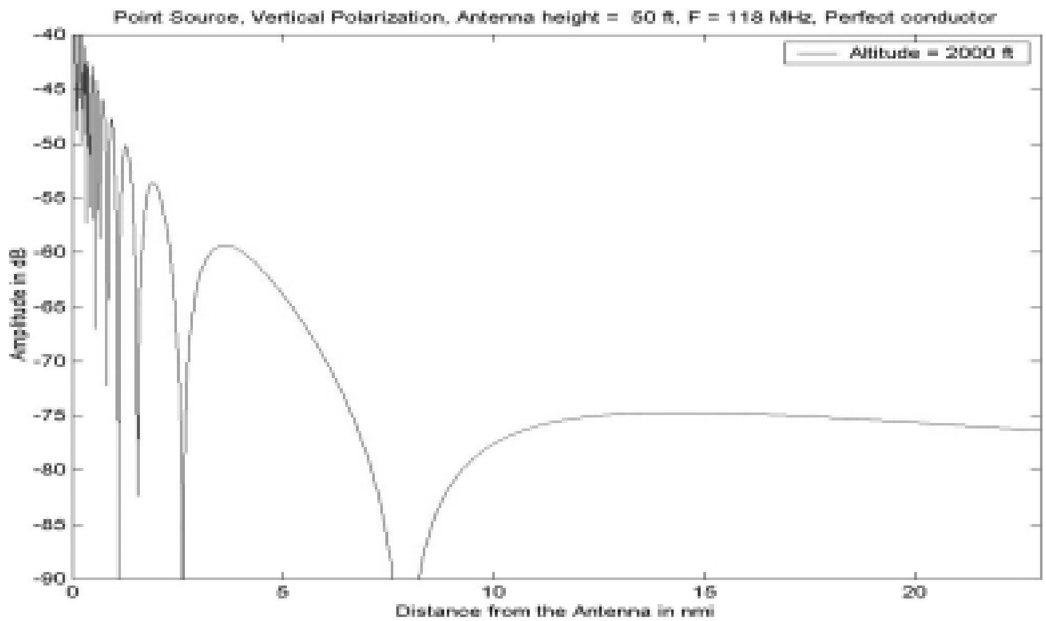

Point Source, Vertical Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 6000 ft
Amplitude in dB
Distance from the Antenna in nmi


Point Source, Vertical Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 7000 ft
Amplitude in dB
Distance from the Antenna in nmi

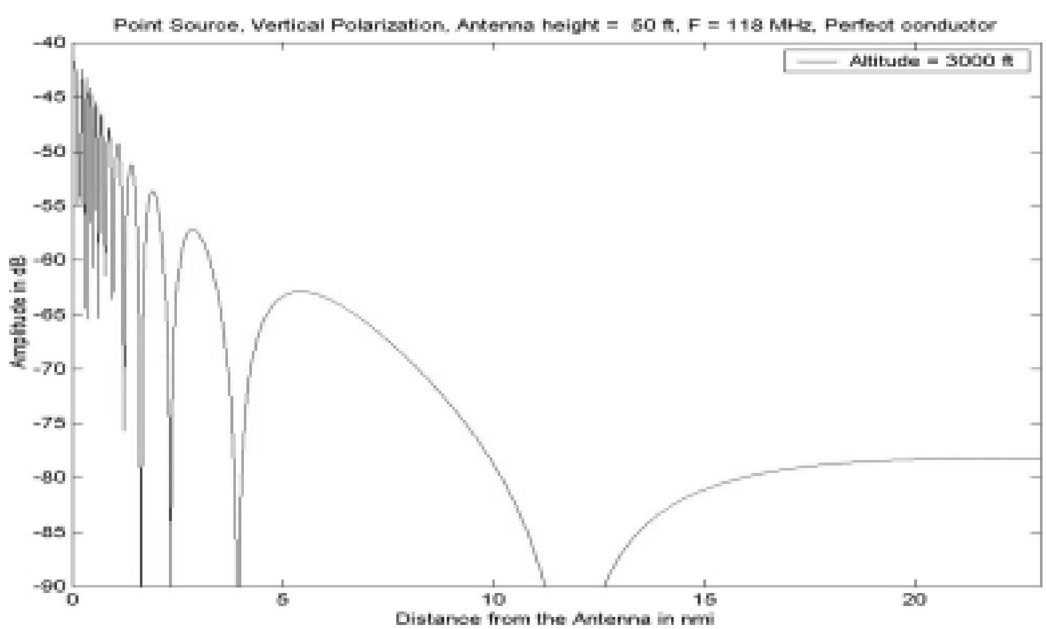

Point Source, Vertical Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 8000 ft
Amplitude in dB
Distance from the Antenna in nmi


Point Source, Vertical Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 9000 ft
Amplitude in dB
Distance from the Antenna in nmi

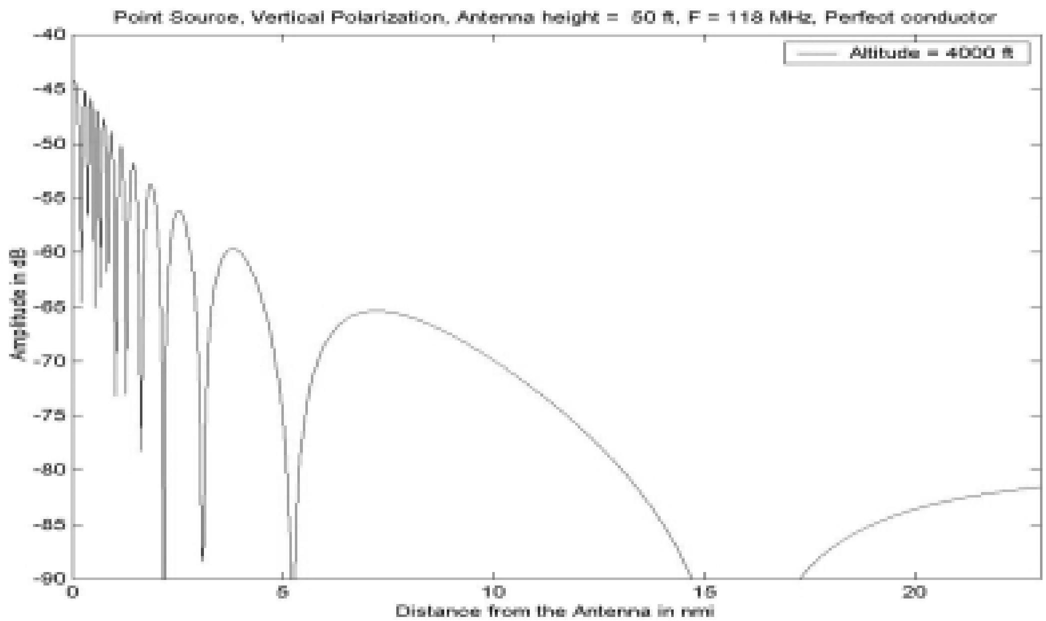

Point Source, Vertical Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 10,000 ft
Amplitude in dB
Distance from the Antenna in nmi

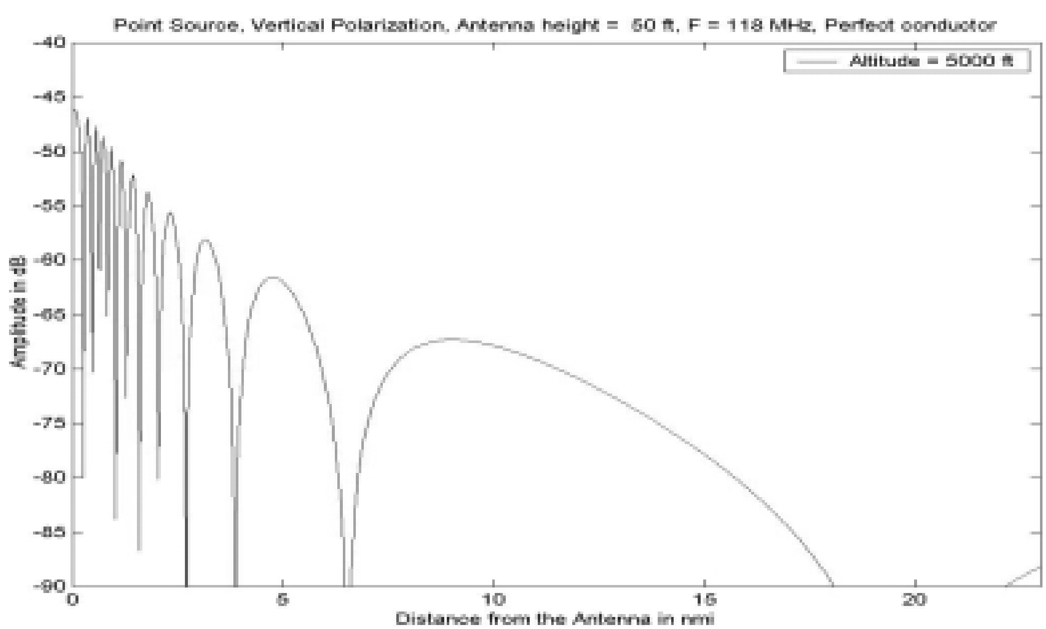


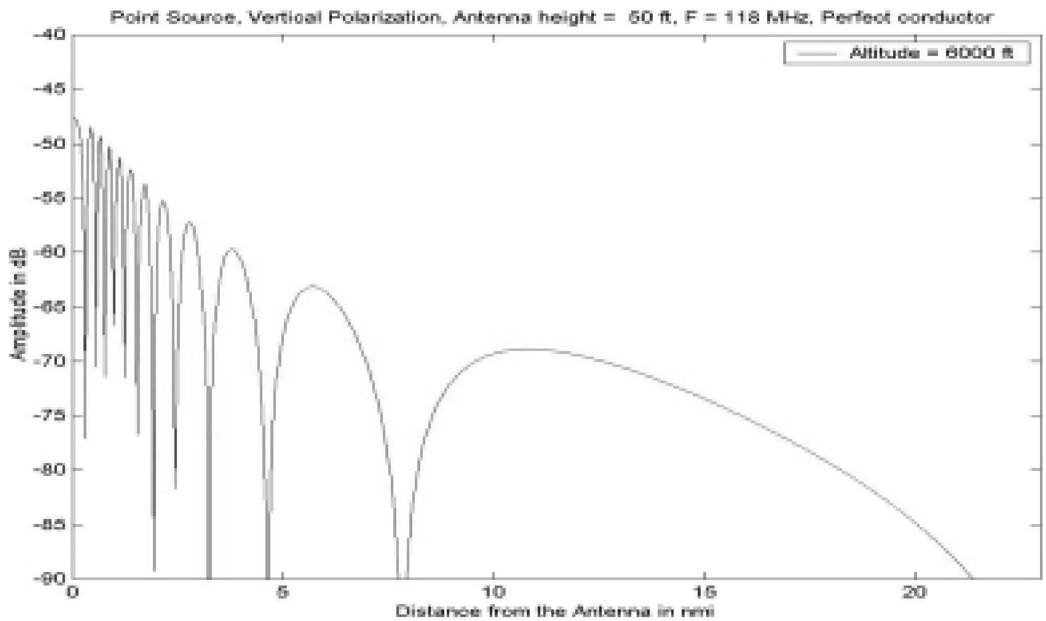
Point Source, Vertical Polarization, Antenna height = 50 ft, F = 118 MHz, Perfect conductor
Altitude = 2000 ft
Amplitude in dB
Distance from the Antenna in nmi



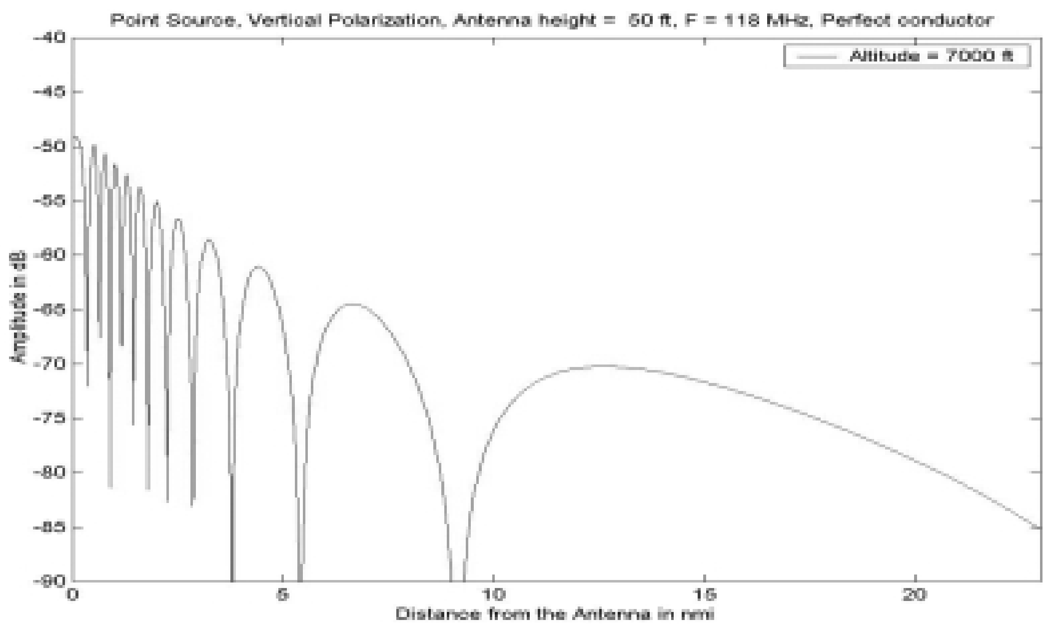
Point Source, Vertical Polarization, Antenna height = 50 ft, F = 118 MHz, Perfect conductor
Altitude = 3000 ft
Amplitude in dB
Distance from the Antenna in nmi


Point Source, Vertical Polarization, Antenna height = 50 ft, F = 118 MHz, Perfect conductor
Altitude = 4000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

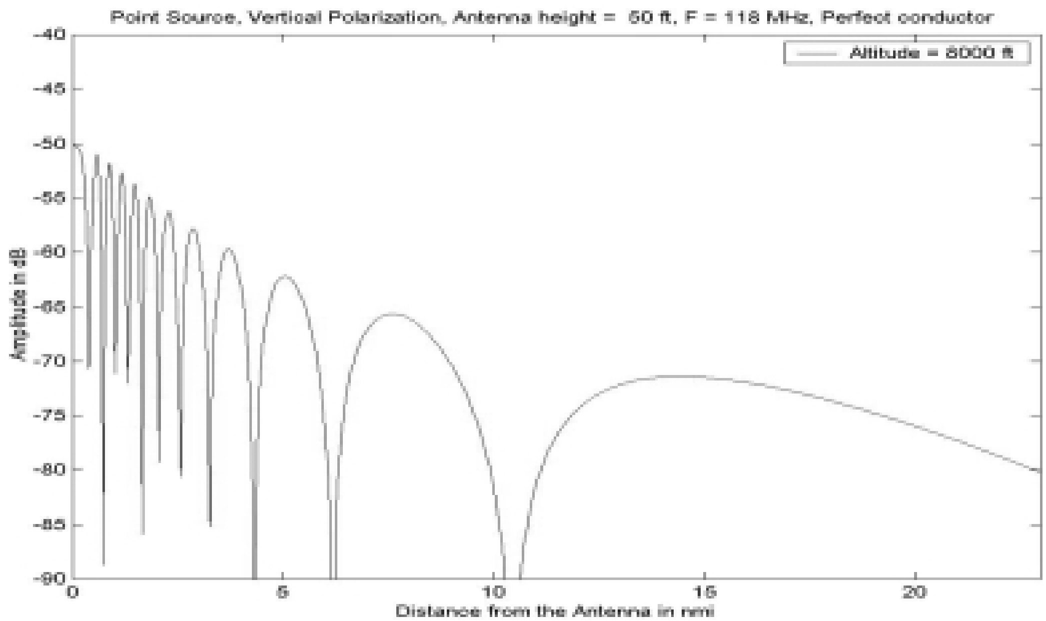

Point Source, Vertical Polarization, Antenna height = 50 ft, F = 118 MHz, Perfect conductor
Altitude = 5000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

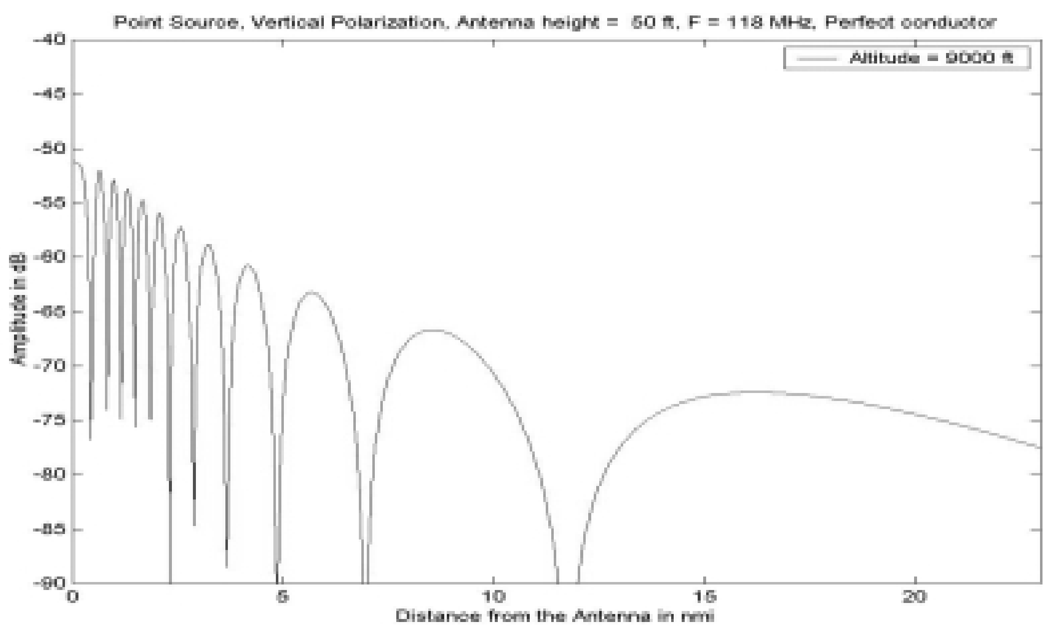


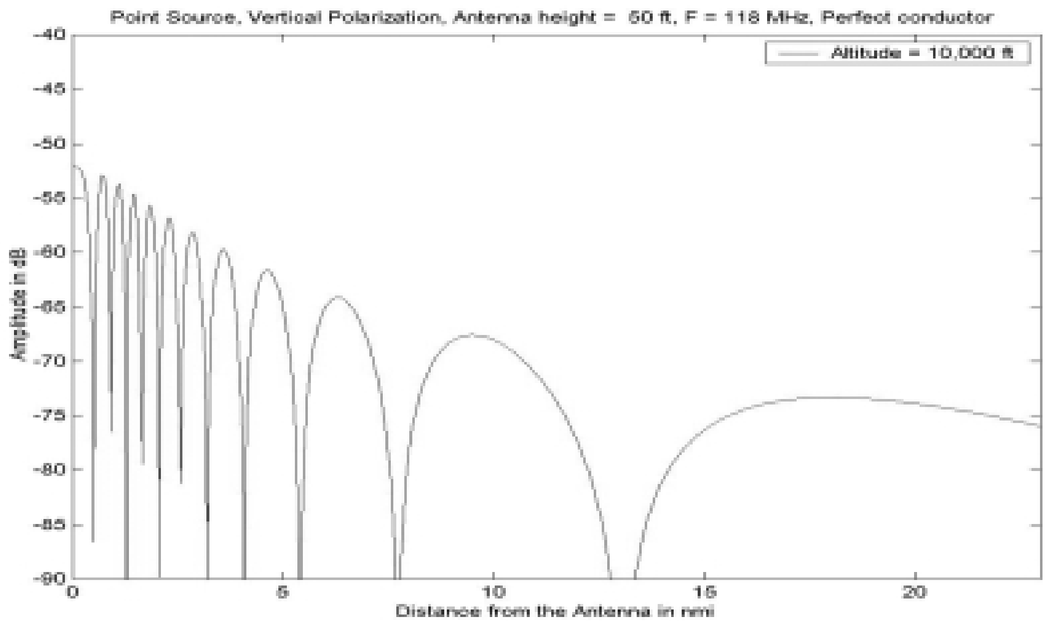
Point Source, Vertical Polarization, Antenna height = 50 ft, F = 118 MHz, Perfect conductor
Altitude = 6000 ft
Amplitude in dB
Distance from the Antenna in nmi

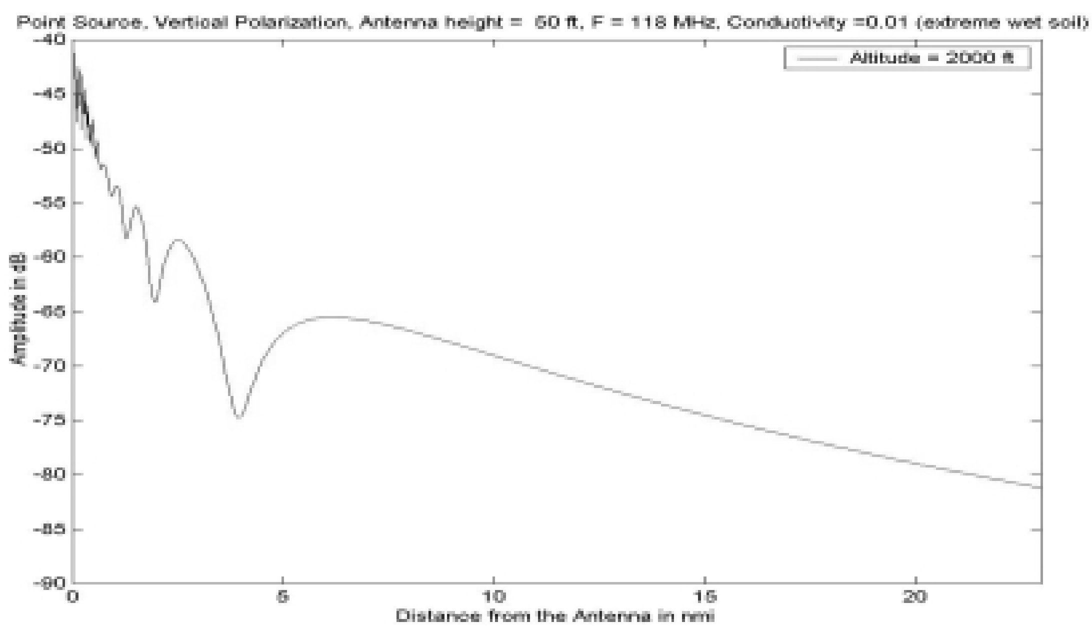


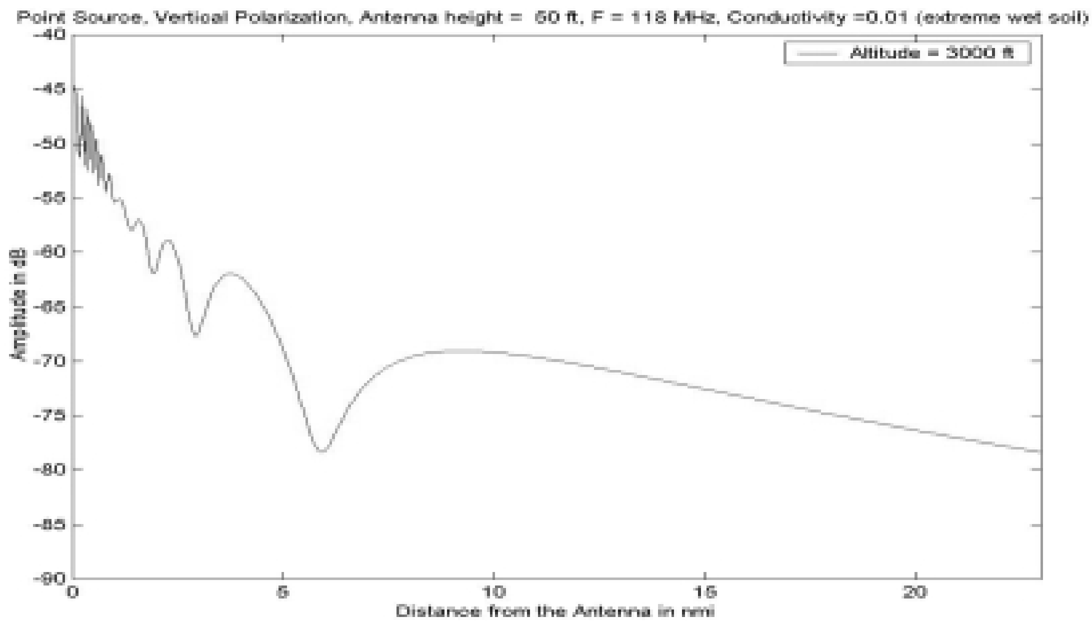
Point Source, Vertical Polarization, Antenna height = 50 ft, F = 118 MHz, Perfect conductor
Altitude = 7000 ft
Amplitude in dB
Distance from the Antenna in nmi

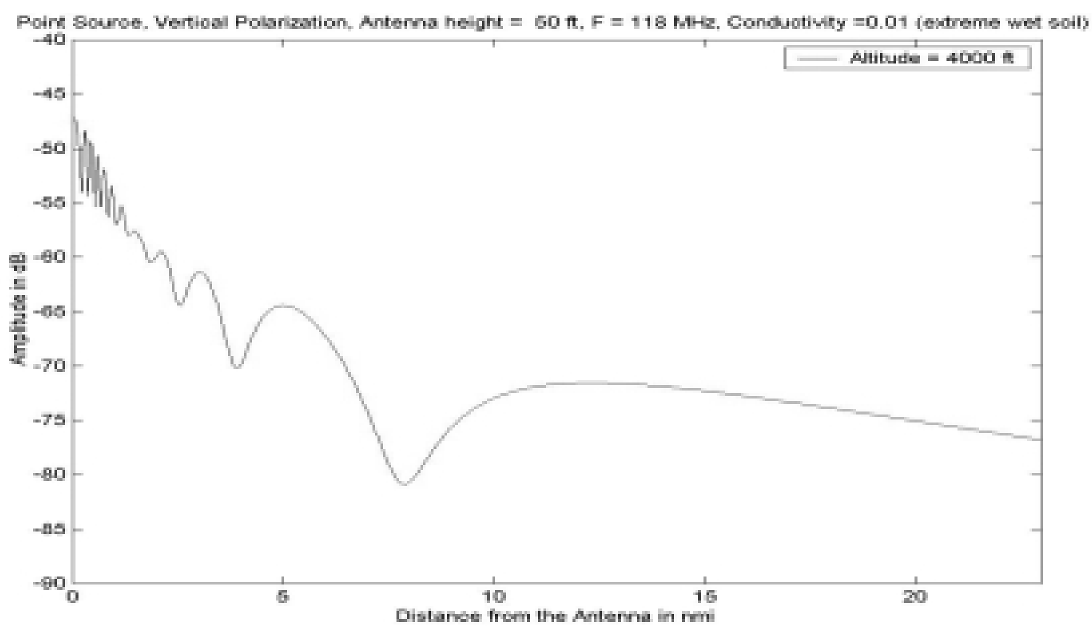

Point Source, Vertical Polarization, Antenna height = 50 ft, F = 118 MHz, Perfect conductor
Altitude = 8000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

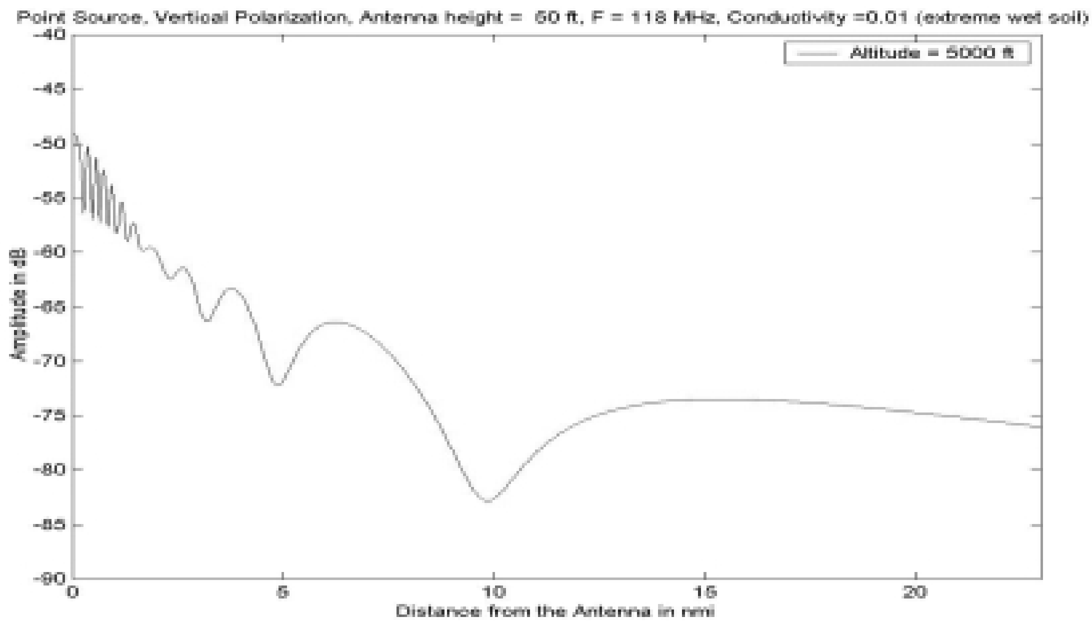

Point Source, Vertical Polarization, Antenna height = 50 ft, F = 118 MHz, Perfect conductor
Altitude = 9000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

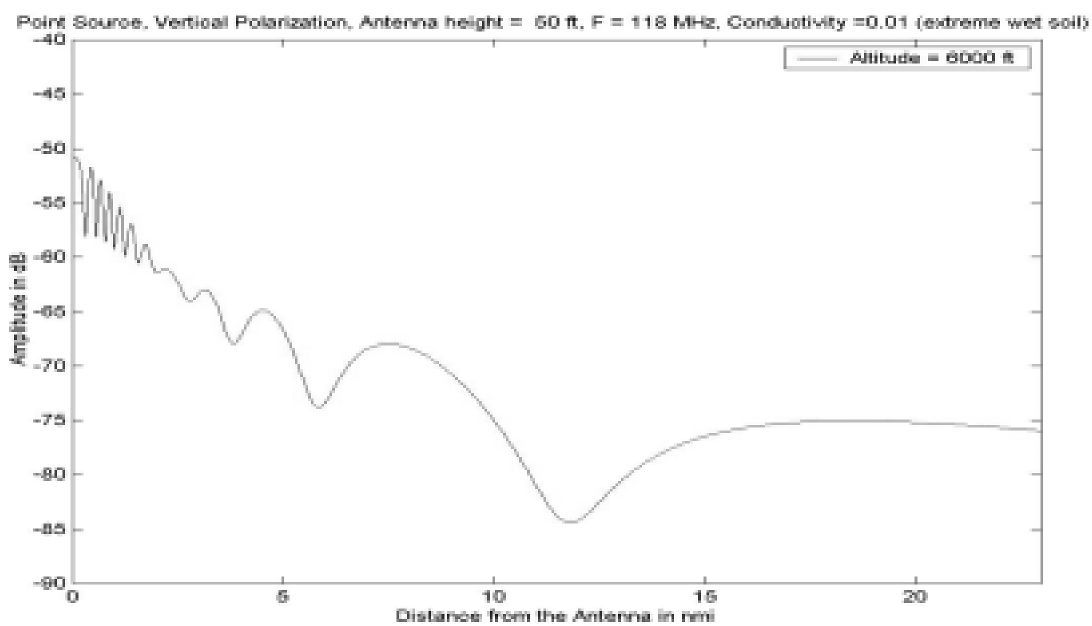

Point Source, Vertical Polarization, Antenna height = 50 ft, F = 118 MHz, Perfect conductor
Altitude = 10,000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

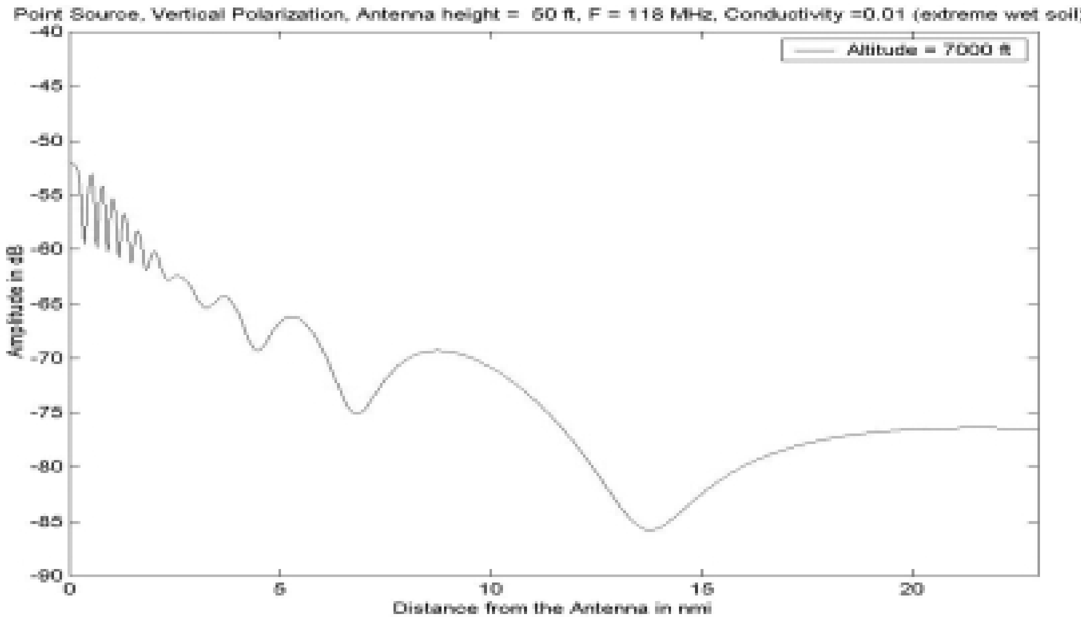

Point Source, Vertical Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 2000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

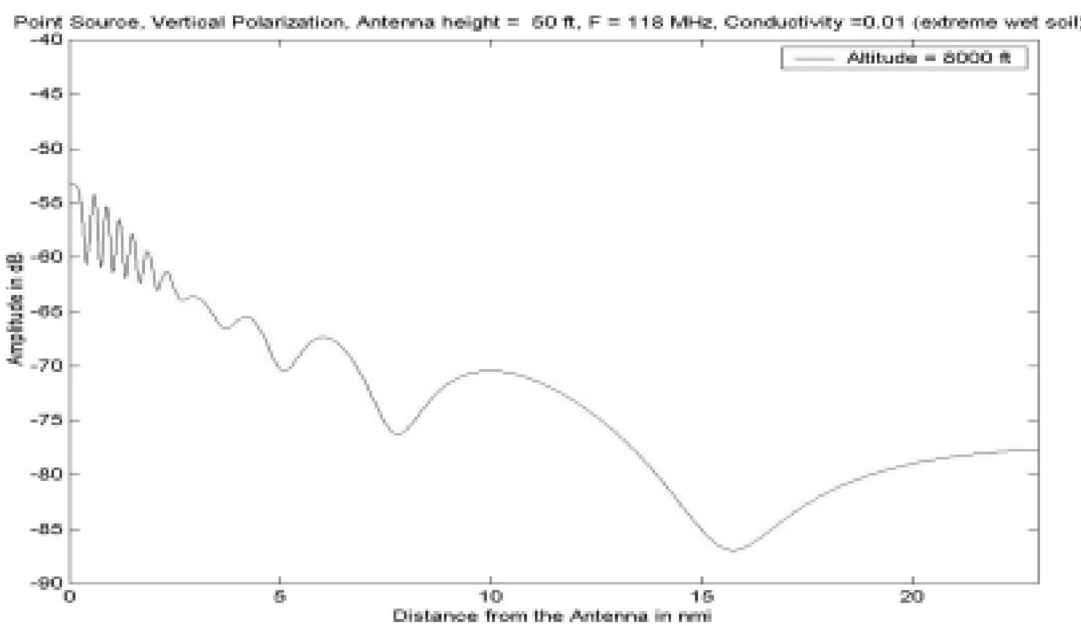

Point Source, Vertical Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 3000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

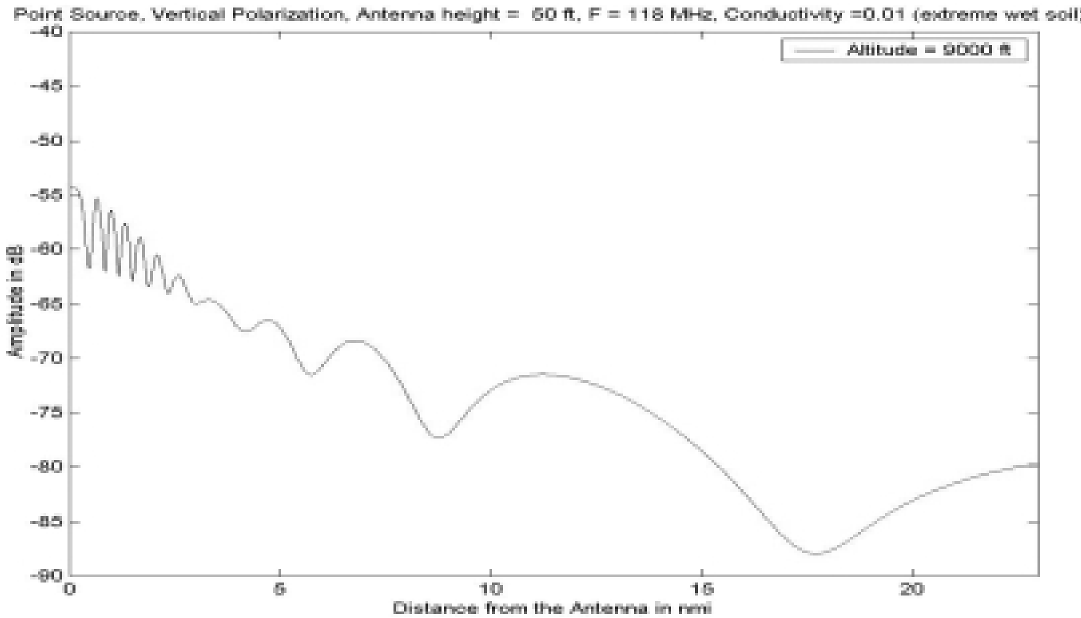

Point Source, Vertical Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 4000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

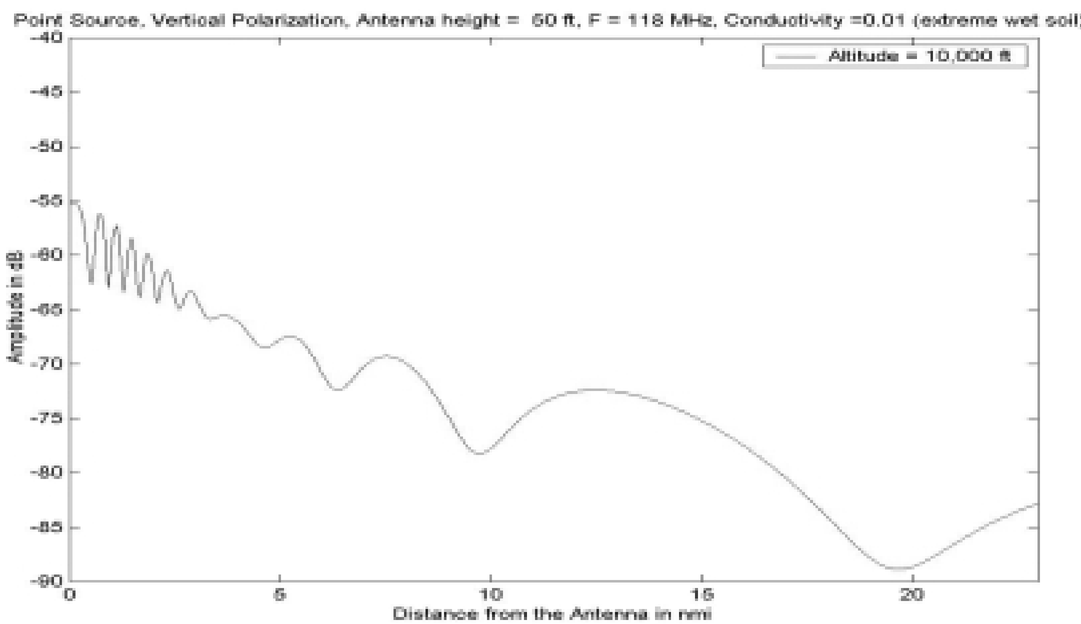

Point Source, Vertical Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 5000 ft
Amplitude in dB
Distance from the Antenna in nmi

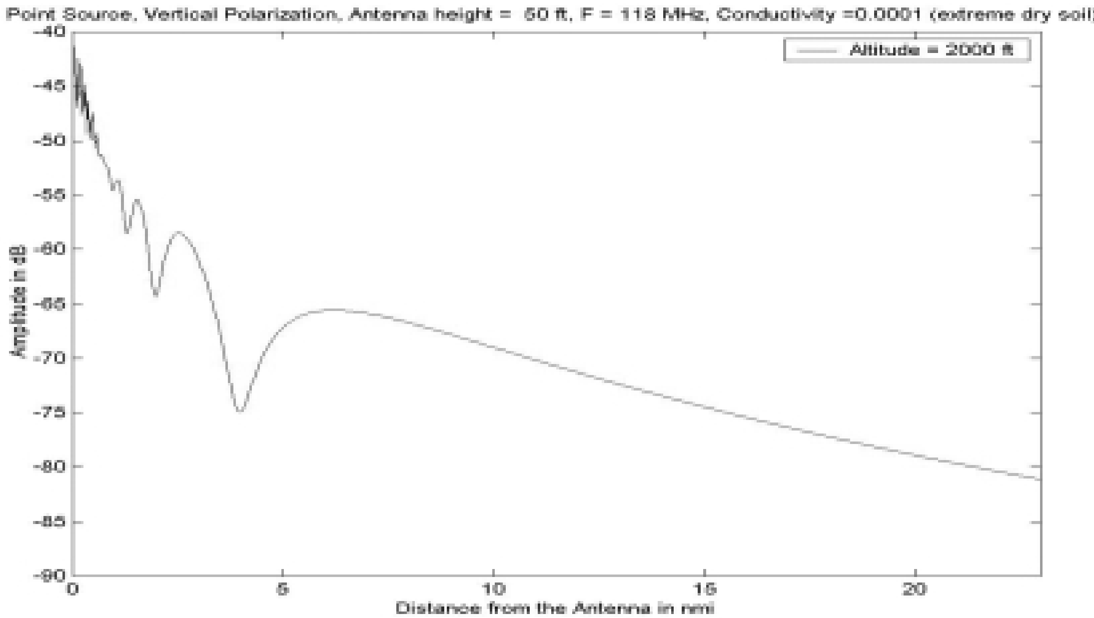

Point Source, Vertical Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 6000 ft
Amplitude in dB
Distance from the Antenna in nmi

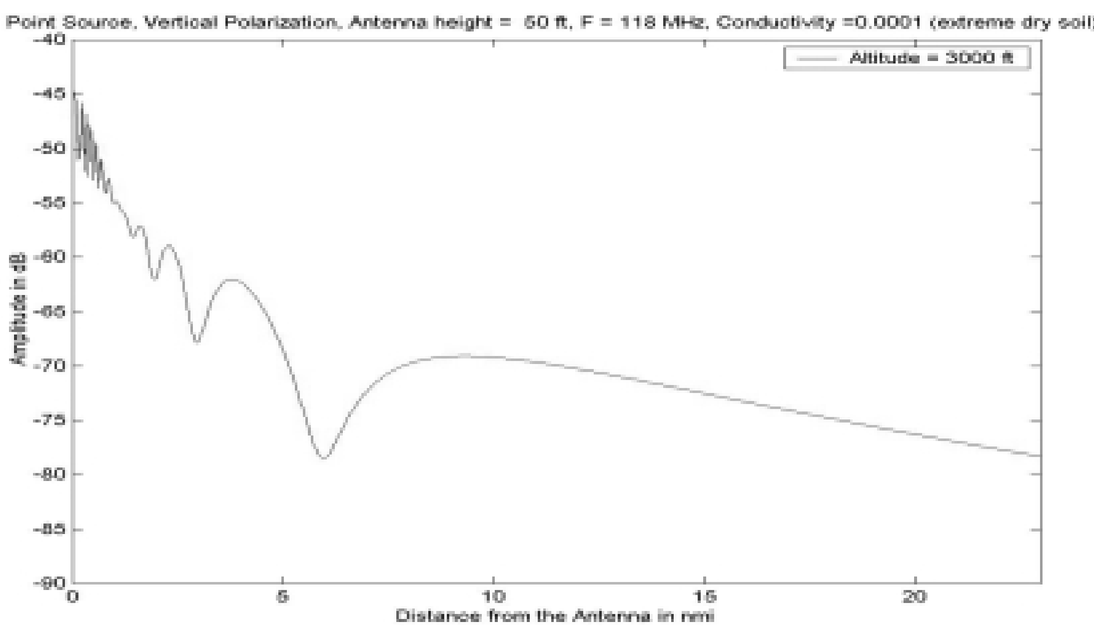

Point Source, Vertical Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 7000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

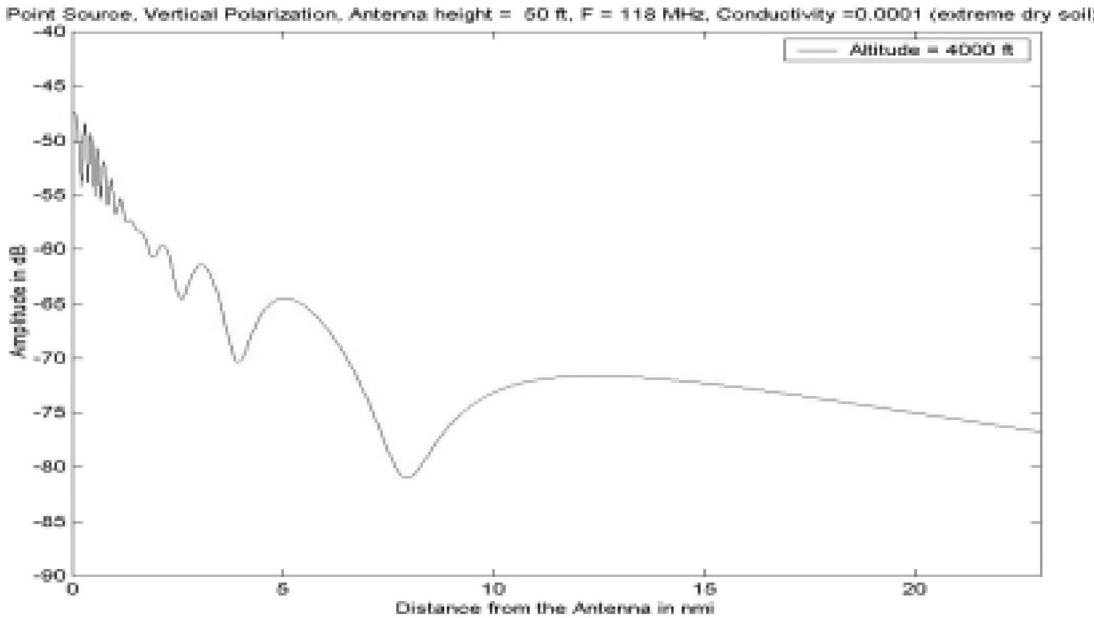

Point Source, Vertical Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 8000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

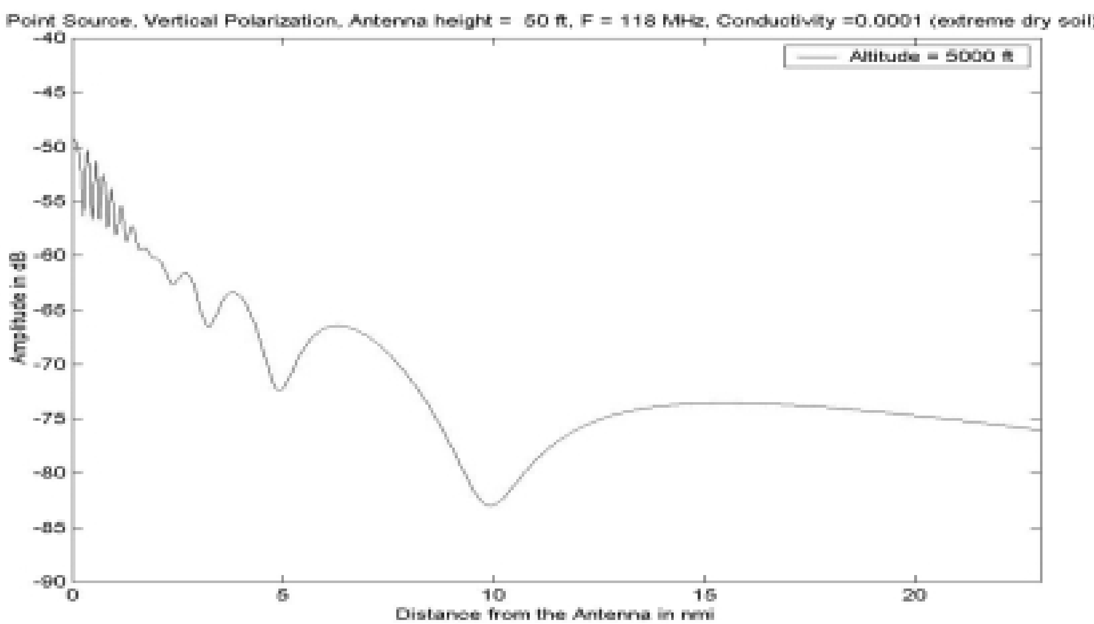

Point Source, Vertical Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 9000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

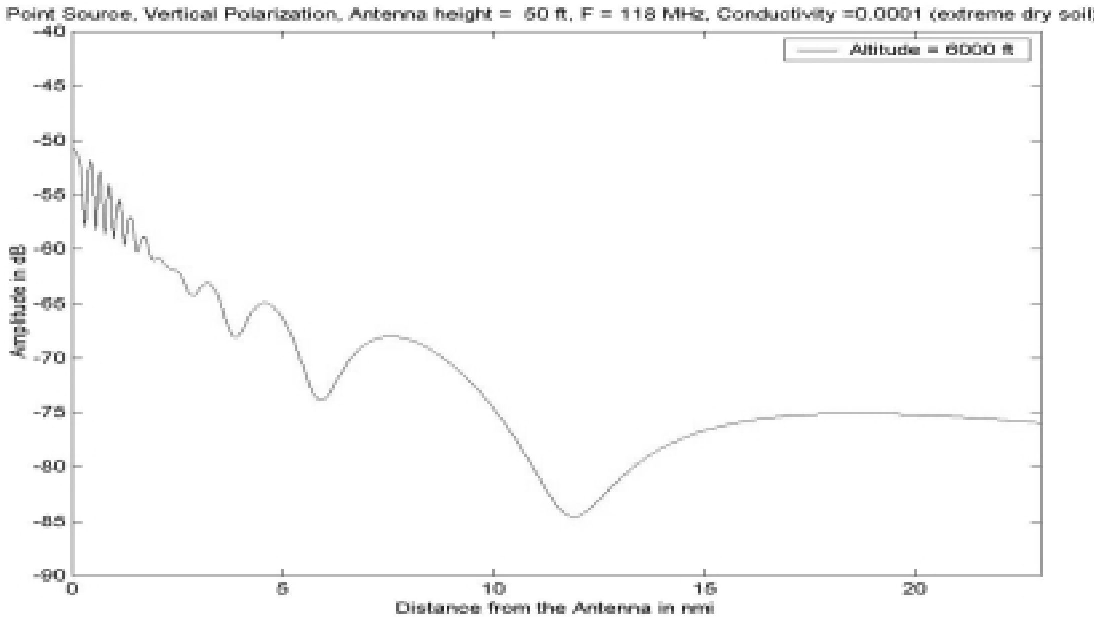

Point Source, Vertical Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 10,000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20


Point Source, Vertical Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 2000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

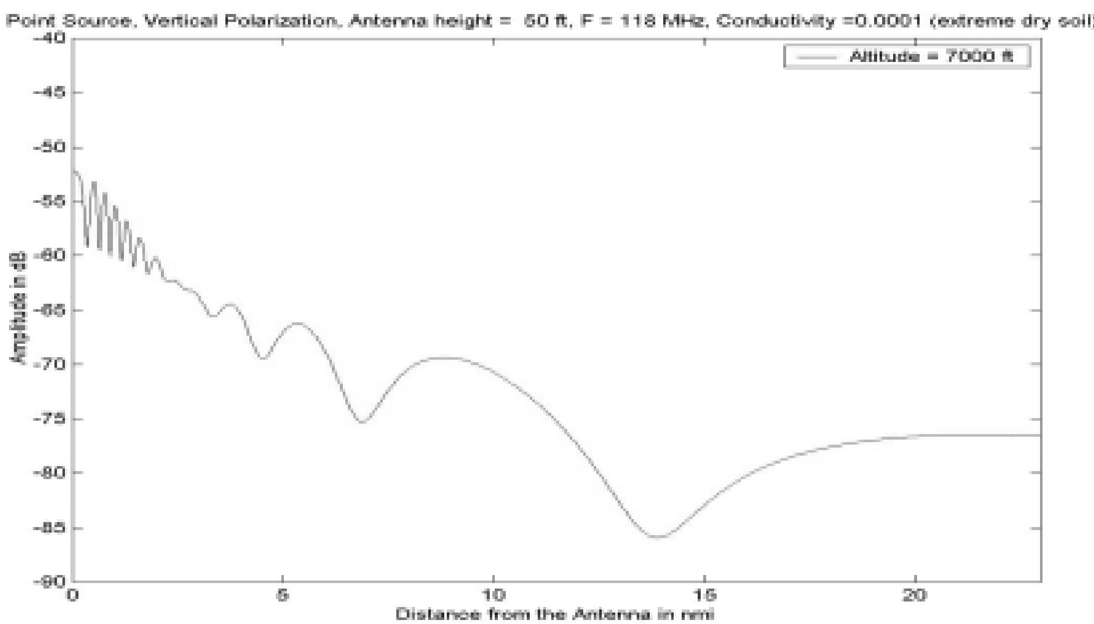

Point Source, Vertical Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 3000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20


Point Source, Vertical Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 4000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

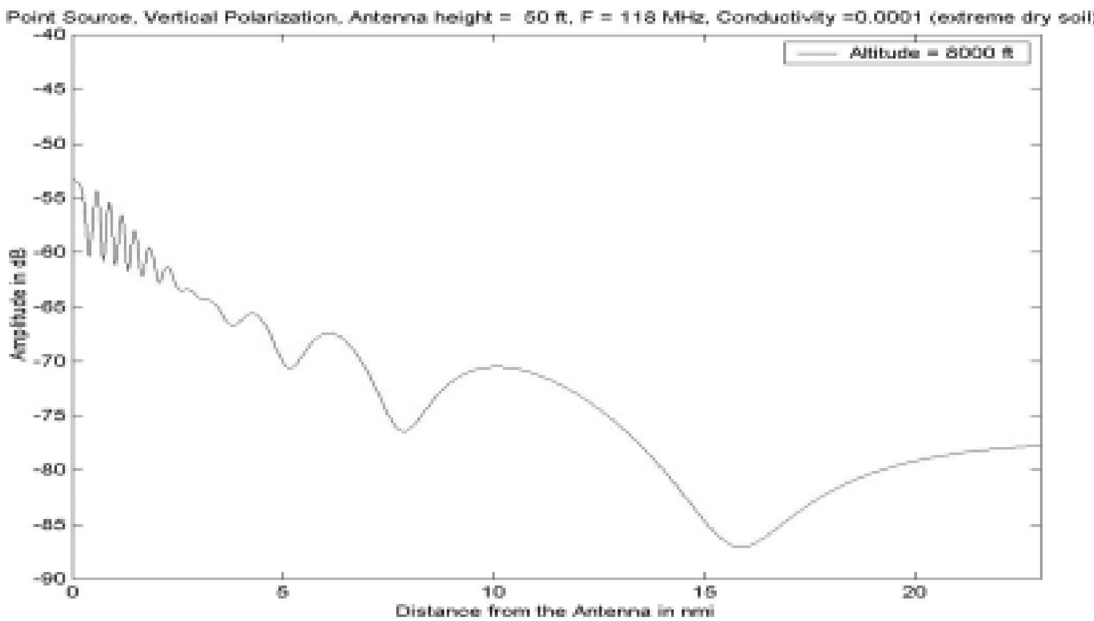

Point Source, Vertical Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 5000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

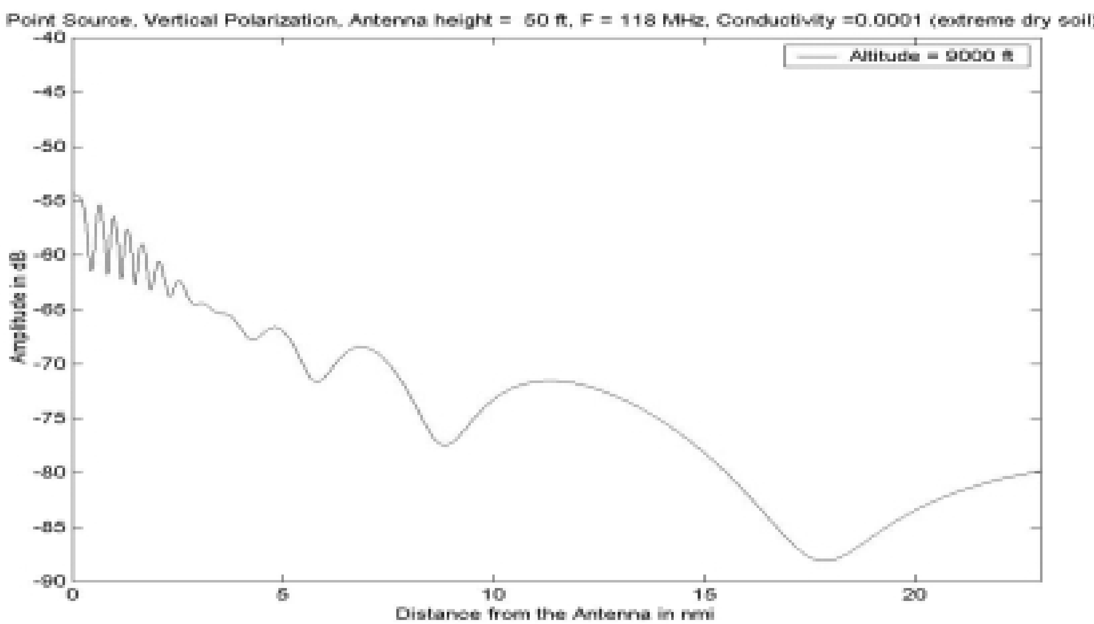


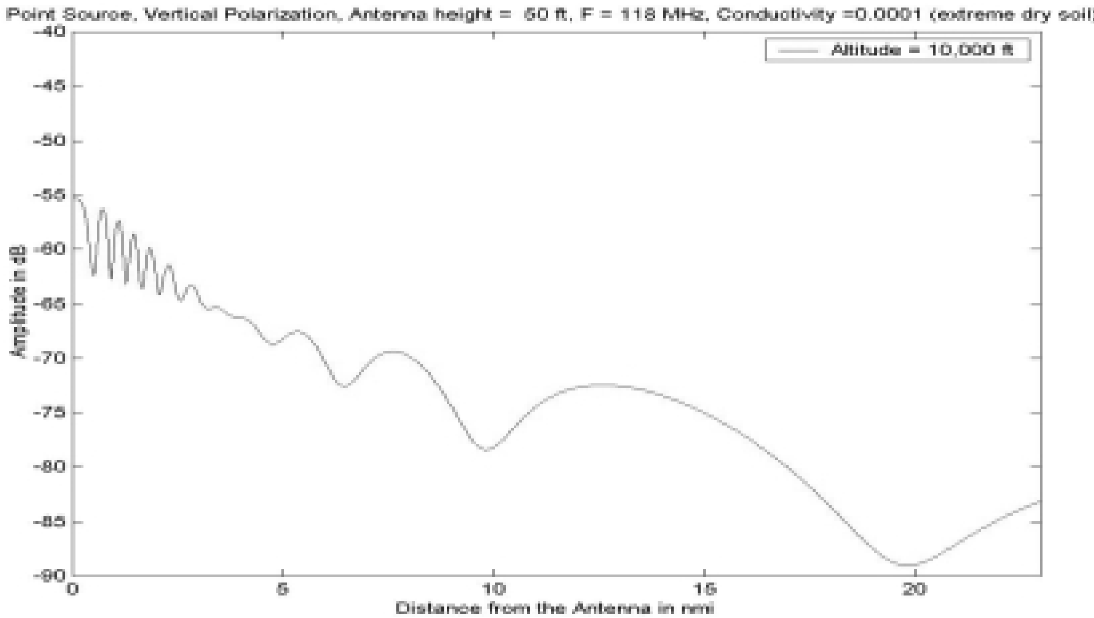
Point Source, Vertical Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 6000 ft
Amplitude in dB
Distance from the Antenna in nmi

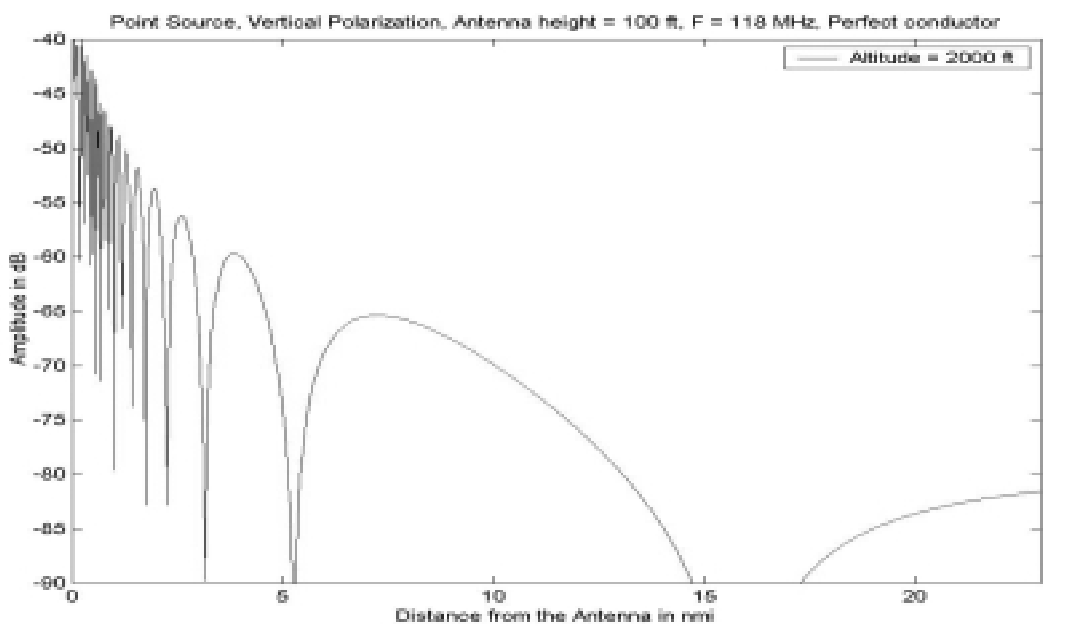


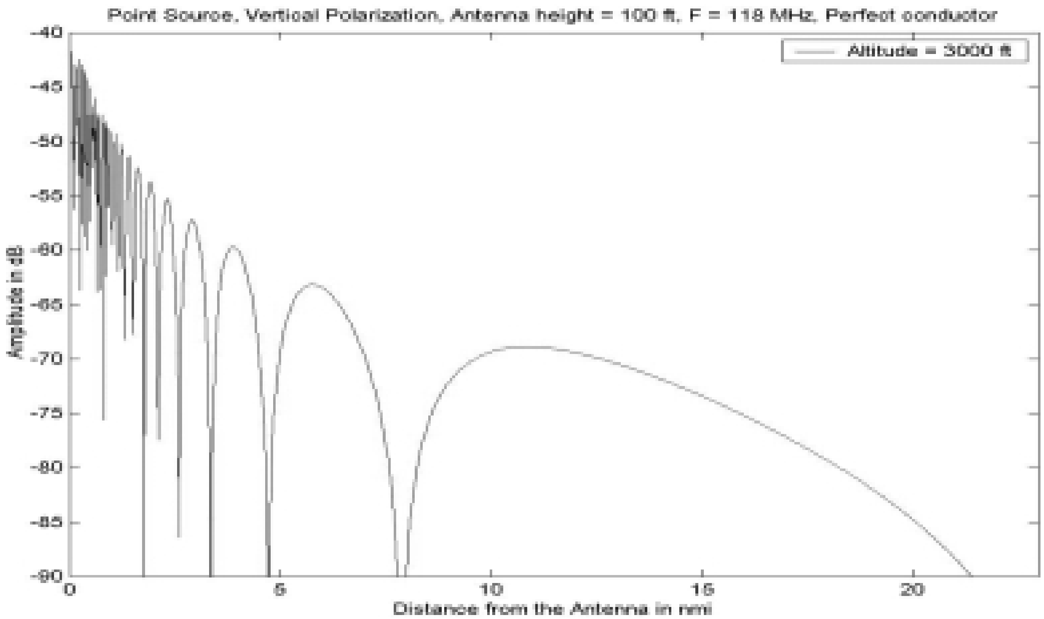
Point Source, Vertical Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 7000 ft
Amplitude in dB
Distance from the Antenna in nmi

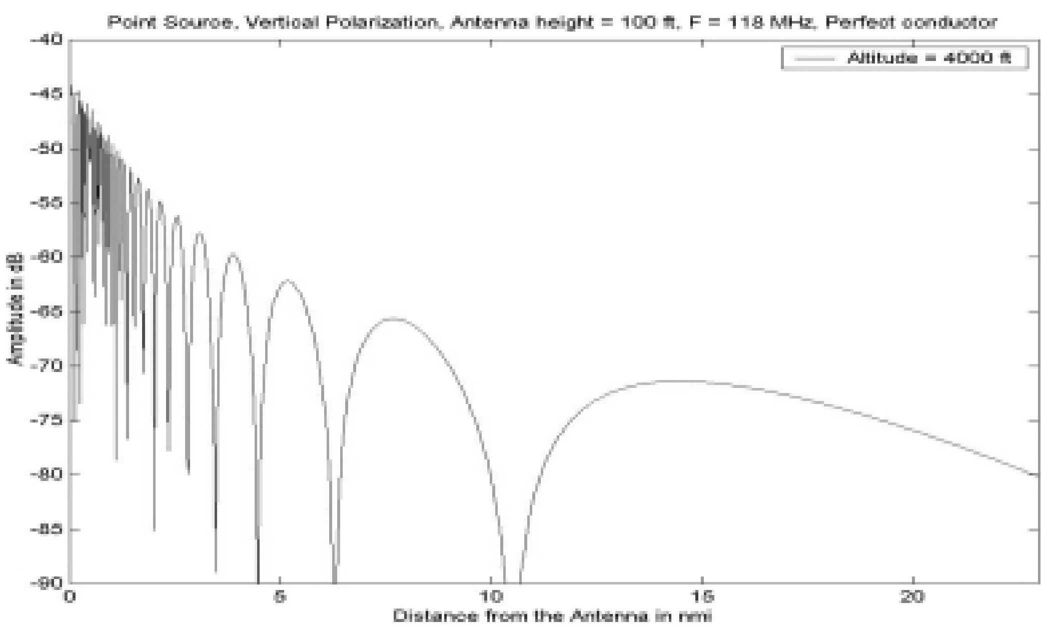

Point Source, Vertical Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 8000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

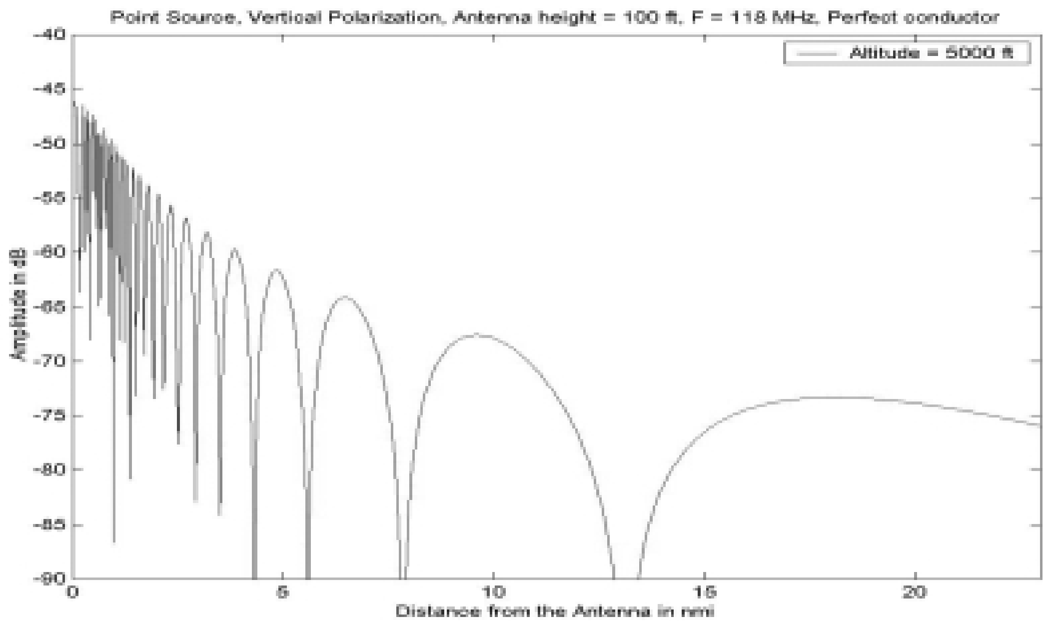

Point Source, Vertical Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 9000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

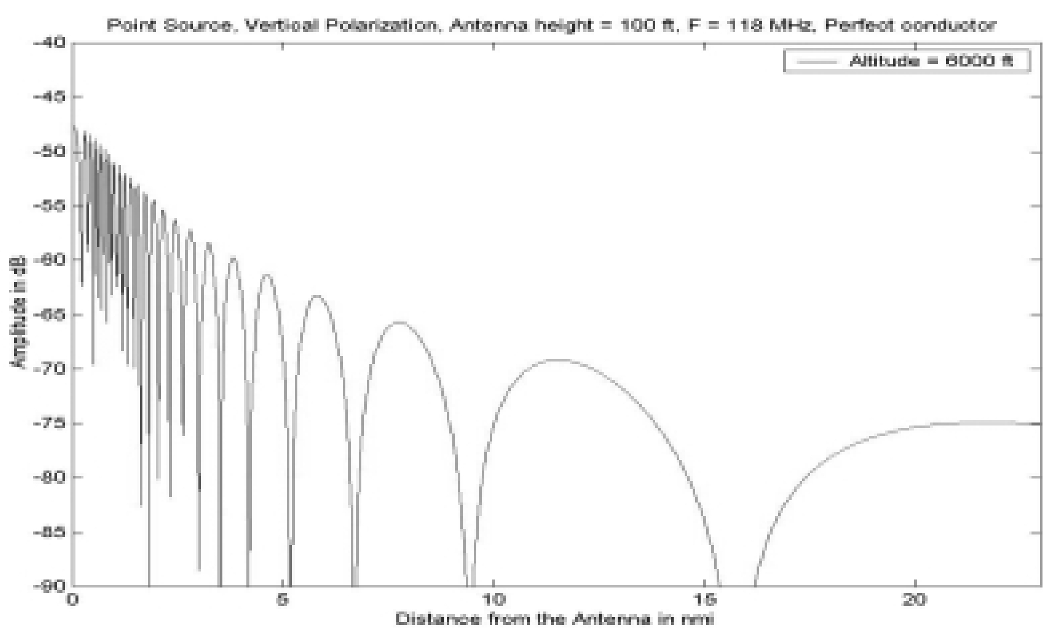

Point Source, Vertical Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 10,000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

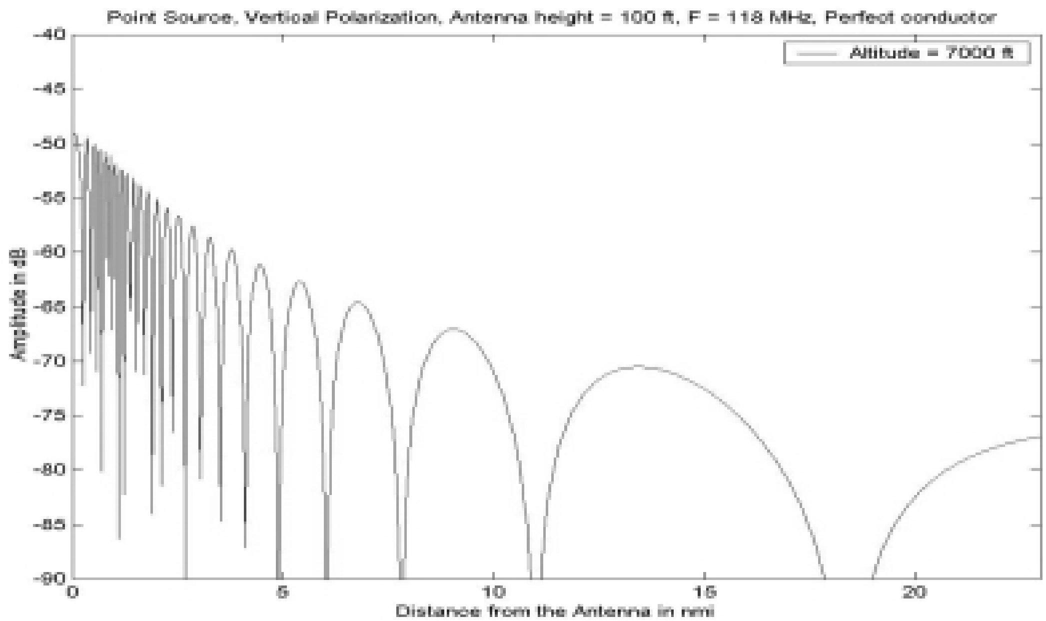

Point Source, Vertical Polarization, Antenna height = 100 ft, F = 118 MHz, Perfect conductor
Altitude = 2000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

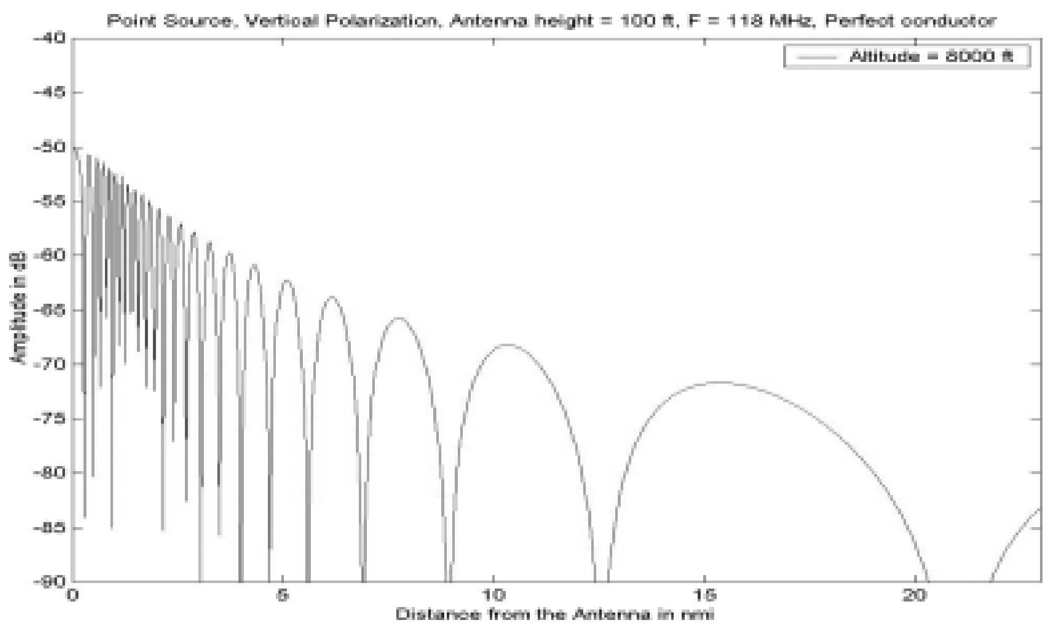

Point Source, Vertical Polarization, Antenna height = 100 ft, F = 118 MHz, Perfect conductor
Altitude = 3000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

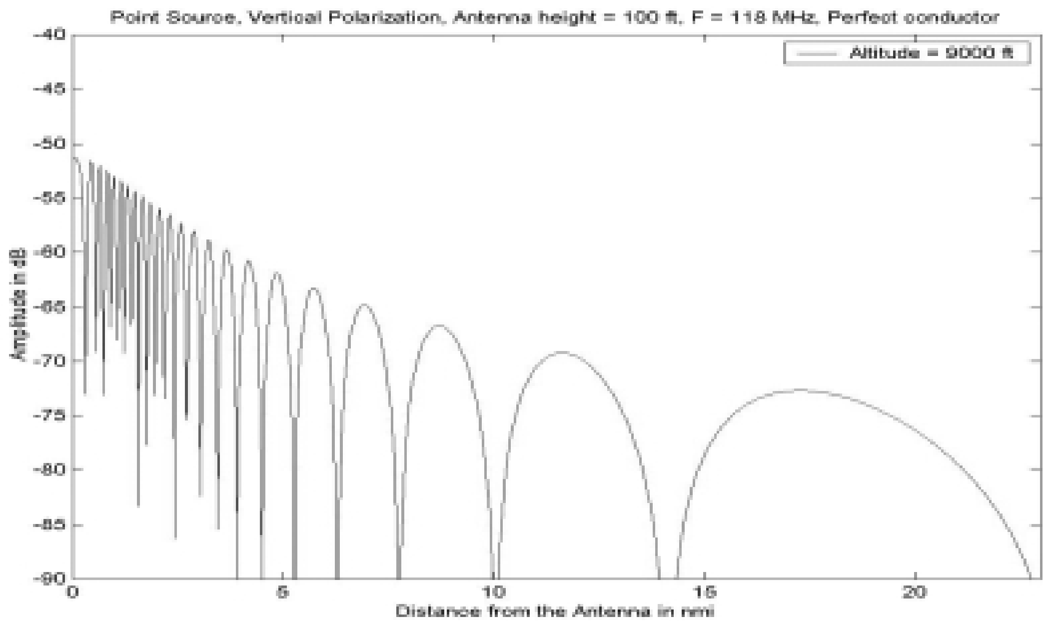

Point Source, Vertical Polarization, Antenna height = 100 ft, F = 118 MHz, Perfect conductor
Altitude = 4000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

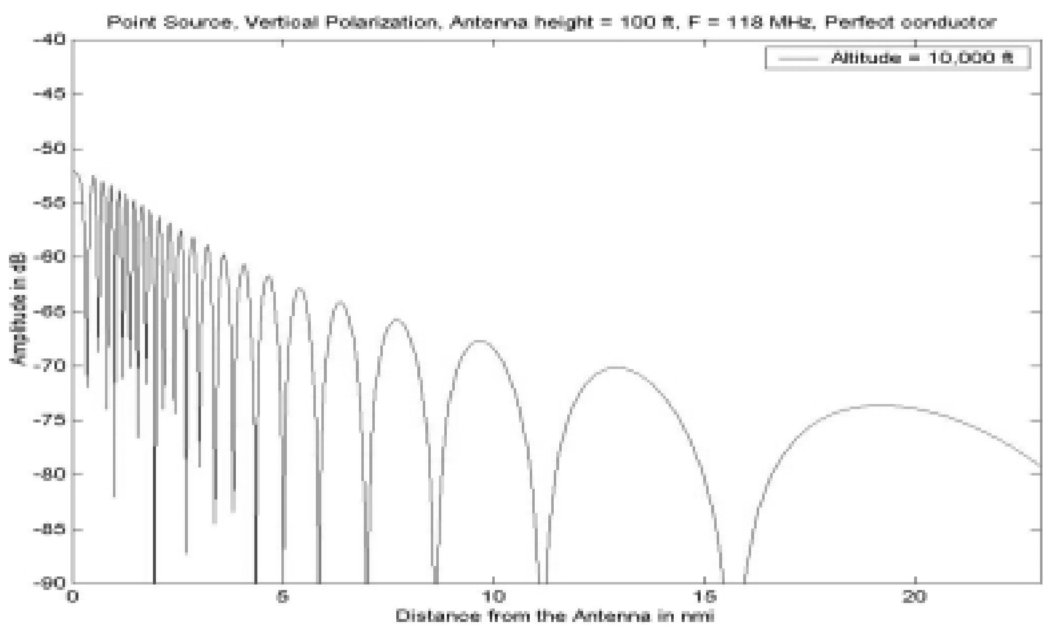

Point Source, Vertical Polarization, Antenna height = 100 ft, F = 118 MHz, Perfect conductor
Altitude = 5000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

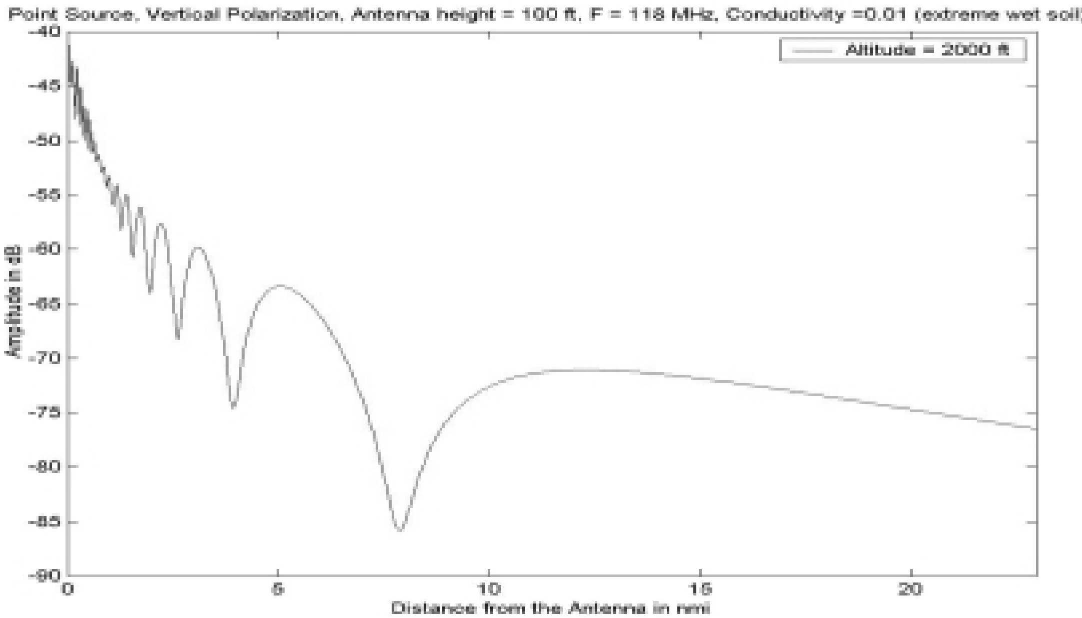

Point Source, Vertical Polarization, Antenna height = 100 ft, F = 118 MHz, Perfect conductor
Altitude = 6000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

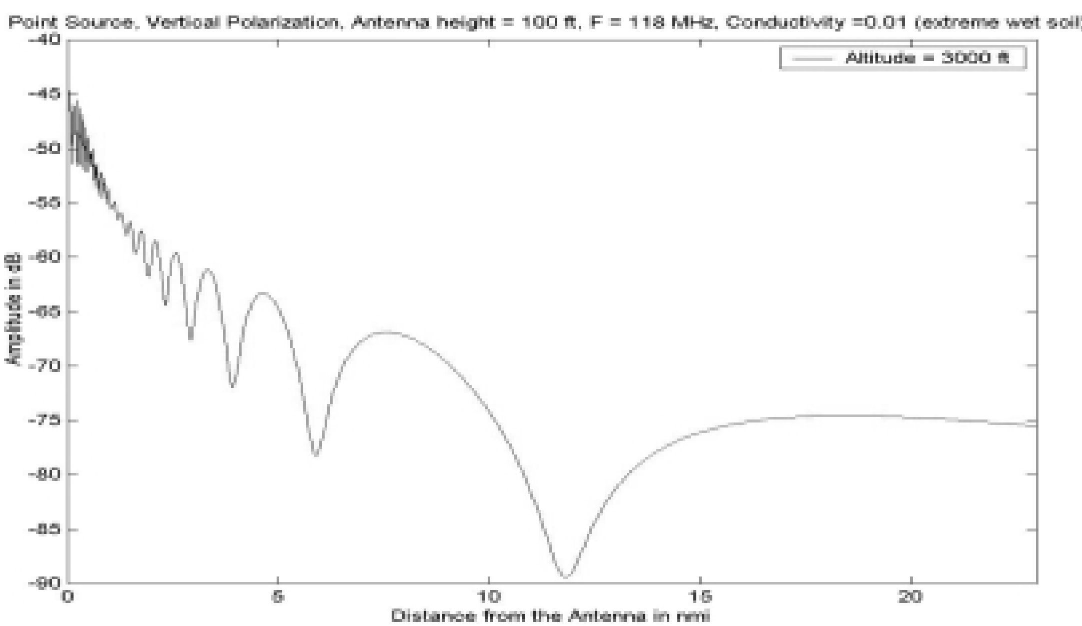

Point Source, Vertical Polarization, Antenna height = 100 ft, F = 118 MHz, Perfect conductor
Altitude = 7000 ft
Amplitude in dB
Distance from the Antenna in nmi

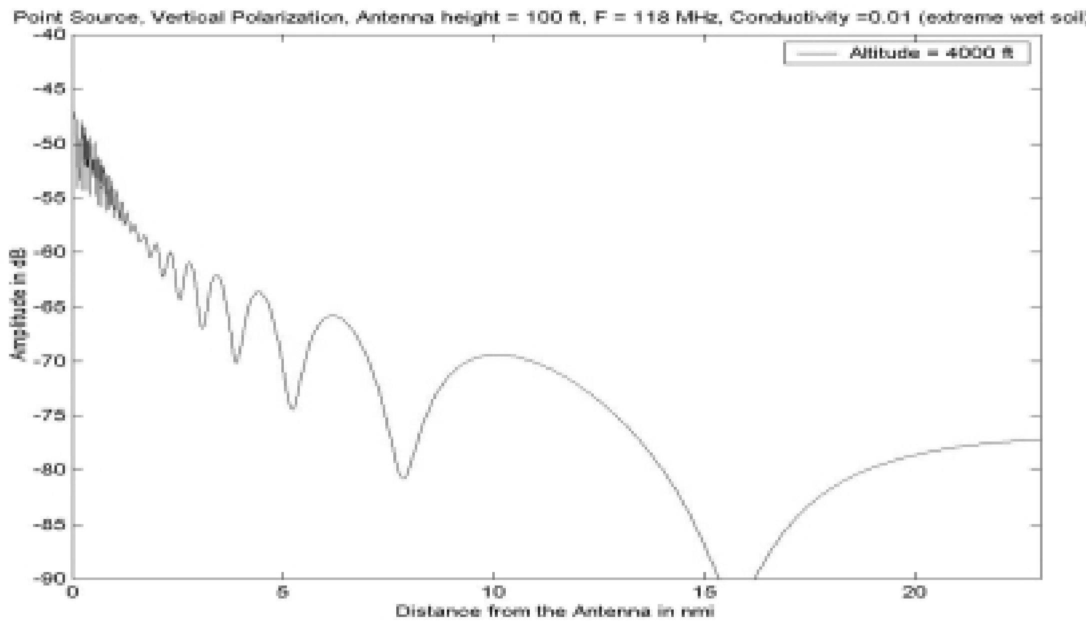

Point Source, Vertical Polarization, Antenna height = 100 ft, F = 118 MHz, Perfect conductor
Altitude = 8000 ft
Amplitude in dB
Distance from the Antenna in nmi

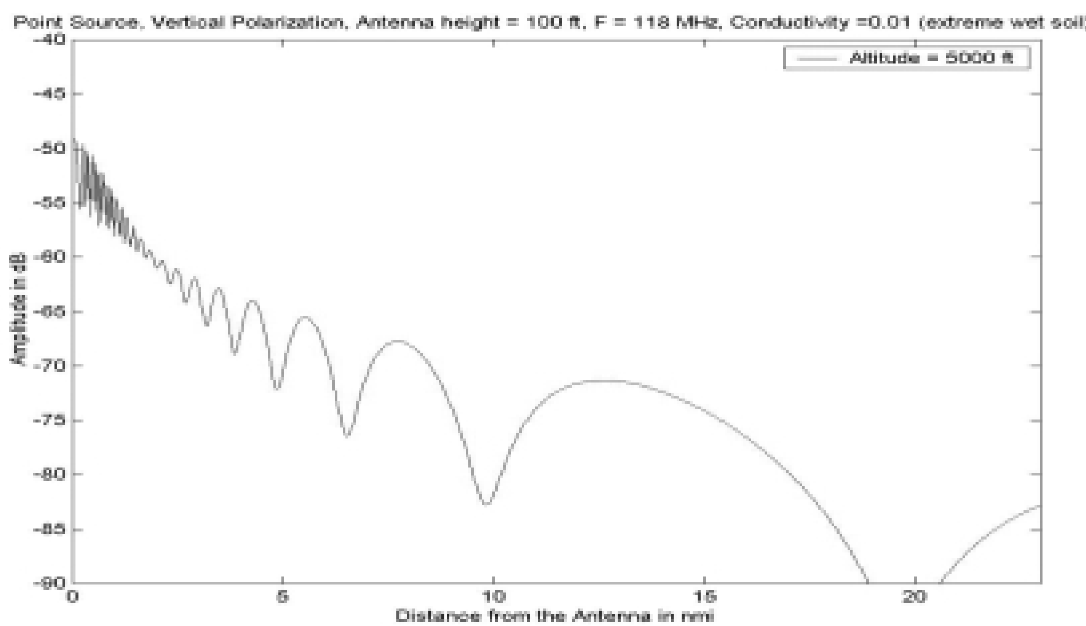

Point Source, Vertical Polarization, Antenna height = 100 ft, F = 118 MHz, Perfect conductor
Altitude = 9000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

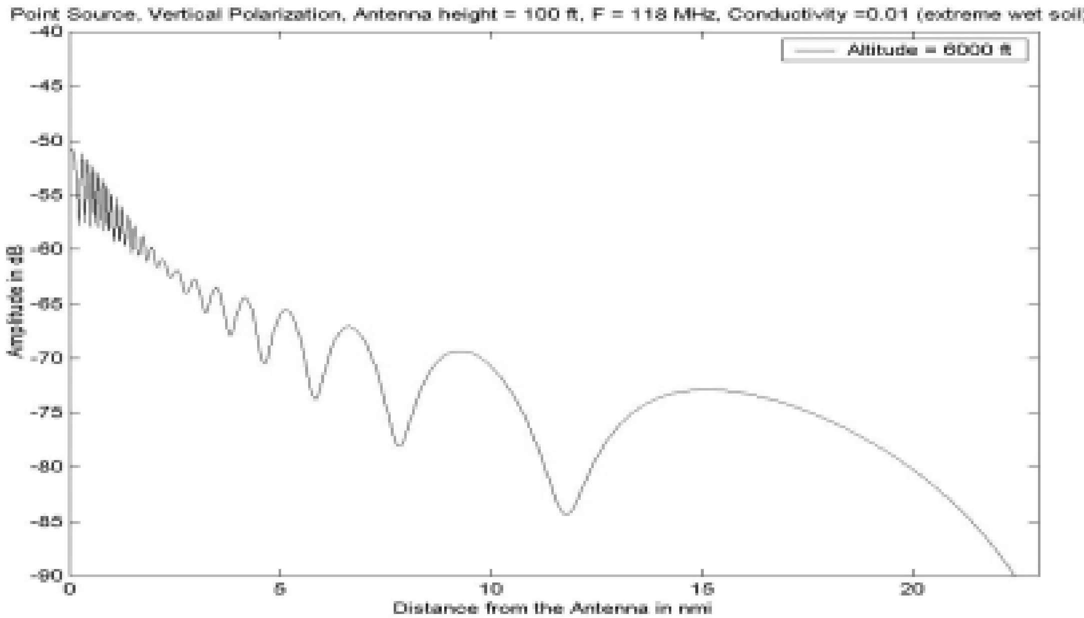

Point Source, Vertical Polarization, Antenna height = 100 ft, F = 118 MHz, Perfect conductor
Altitude = 10,000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

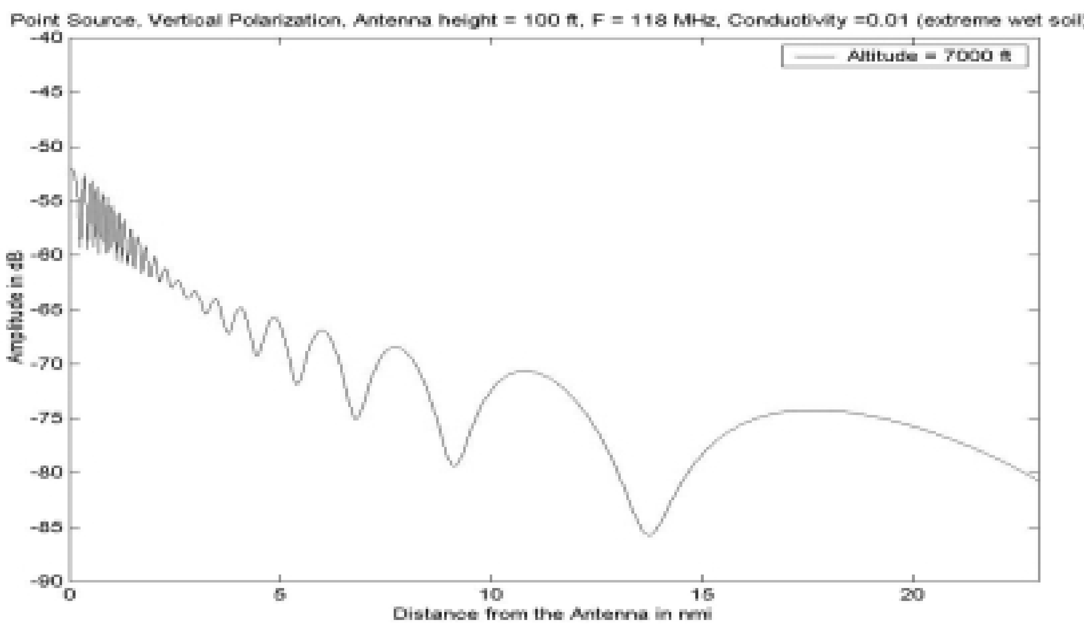

Point Source, Vertical Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 2000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

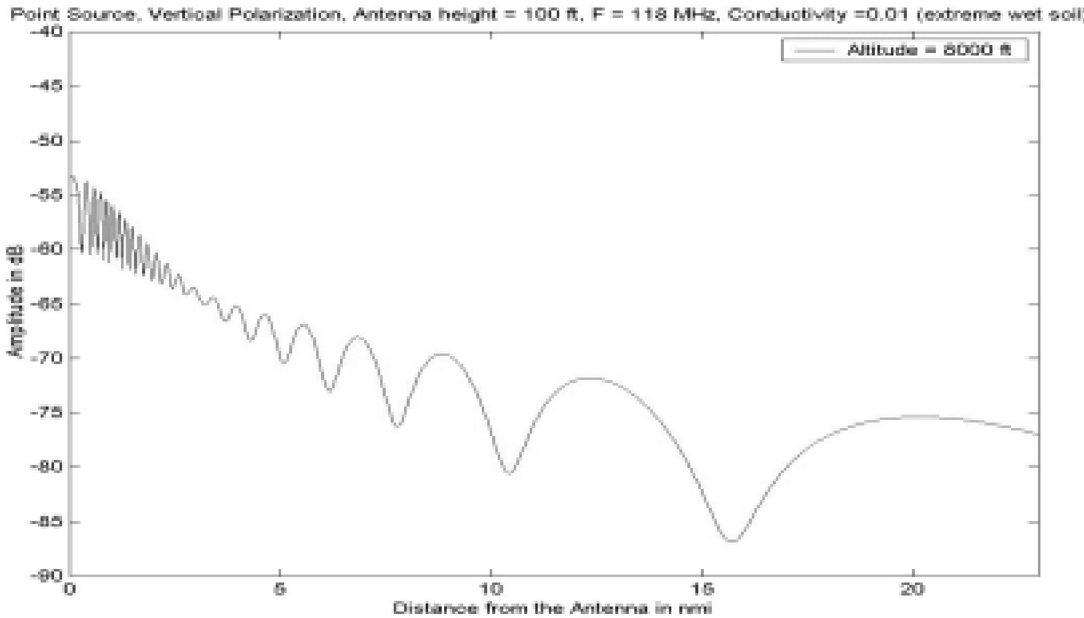

Point Source, Vertical Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 3000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

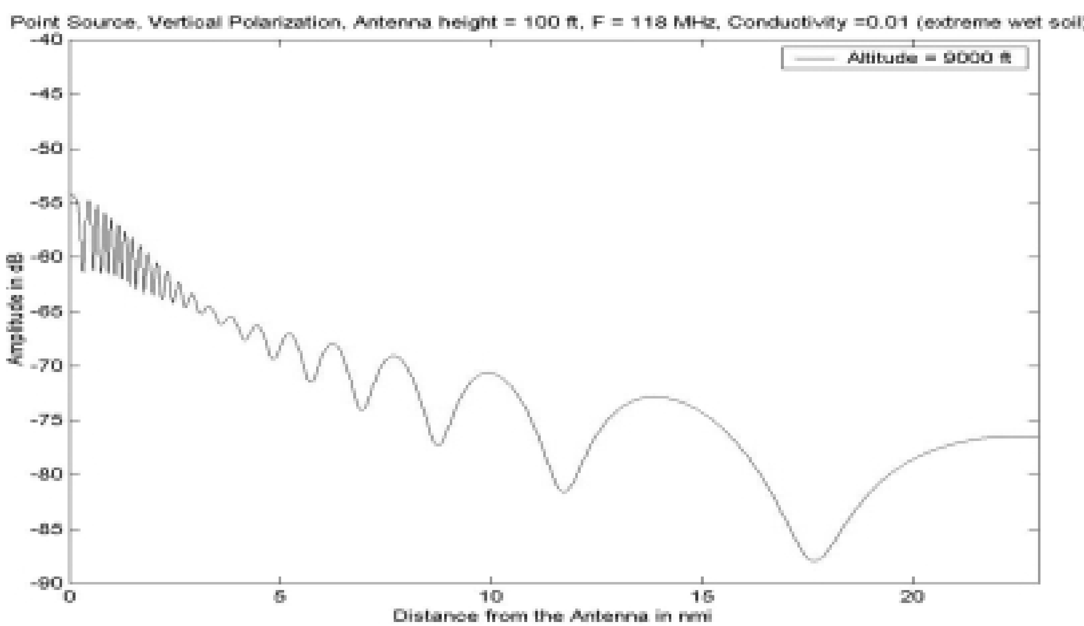

Point Source, Vertical Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 4000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

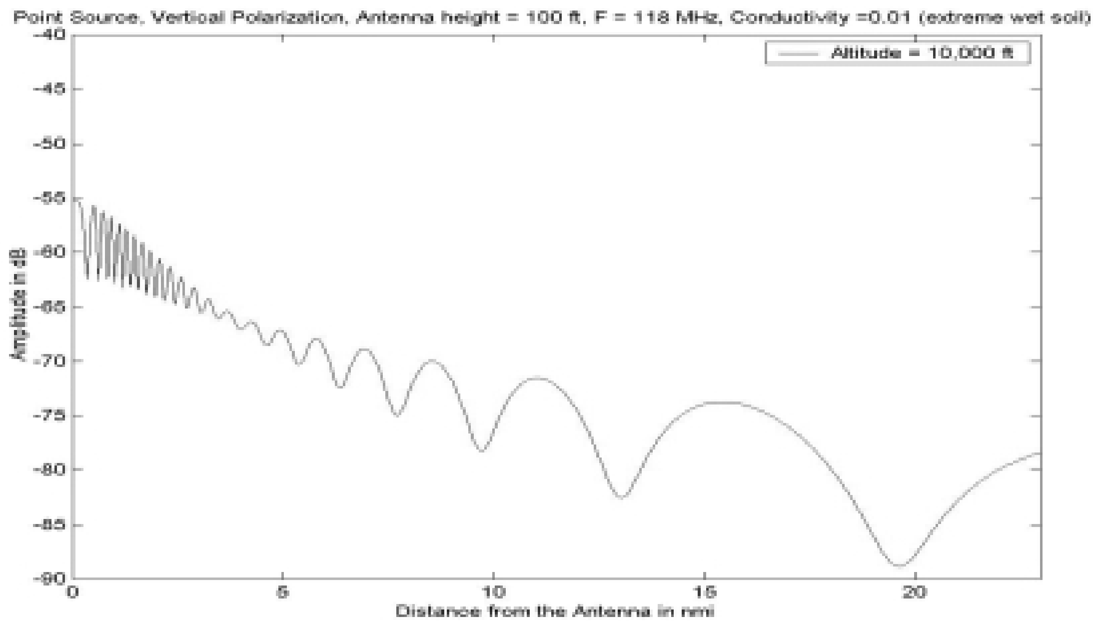

Point Source, Vertical Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 5000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20


Point Source, Vertical Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 6000 ft
Amplitude in dB
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20
Distance from the Antenna in nmi

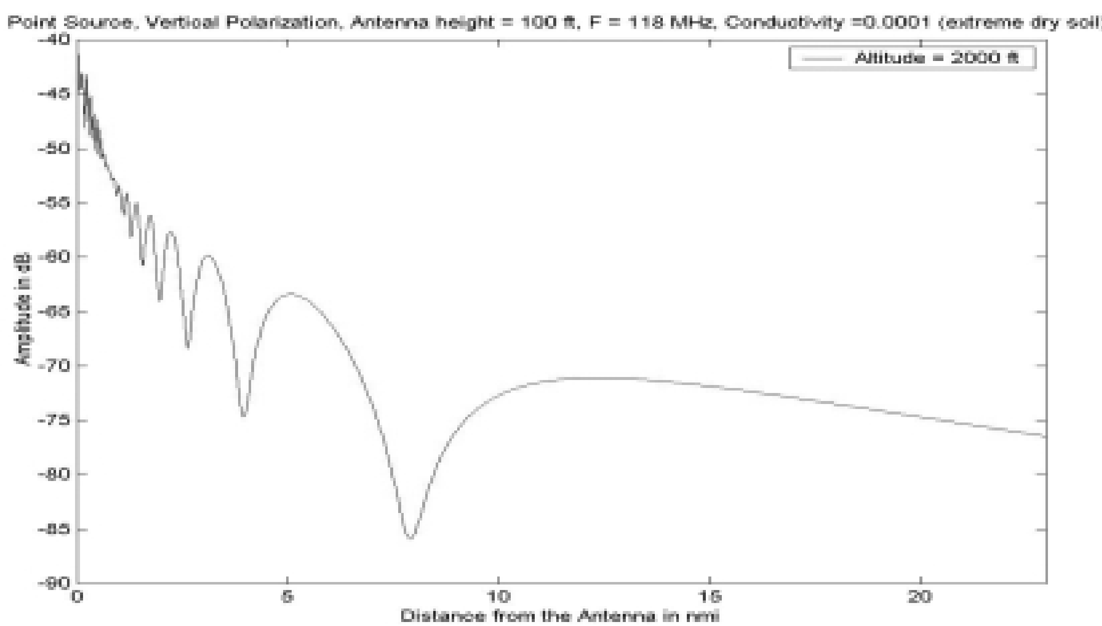

Point Source, Vertical Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 7000 ft
Amplitude in dB
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20
Distance from the Antenna in nmi


Point Source, Vertical Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 8000 ft
Amplitude in dB
Distance from the Antenna in nmi

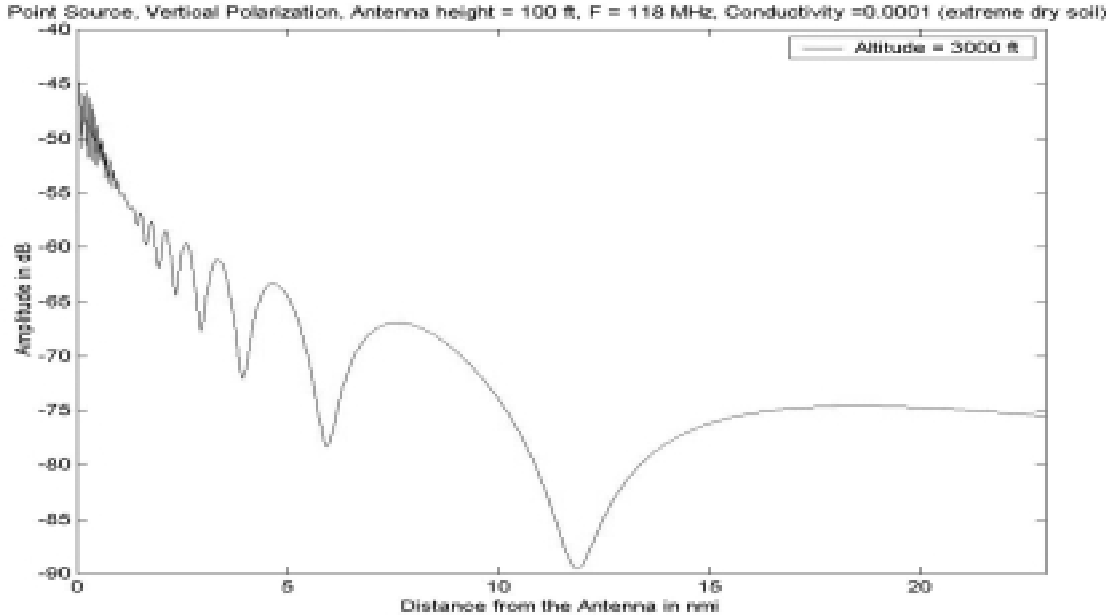

Point Source, Vertical Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 9000 ft
Amplitude in dB
Distance from the Antenna in nmi

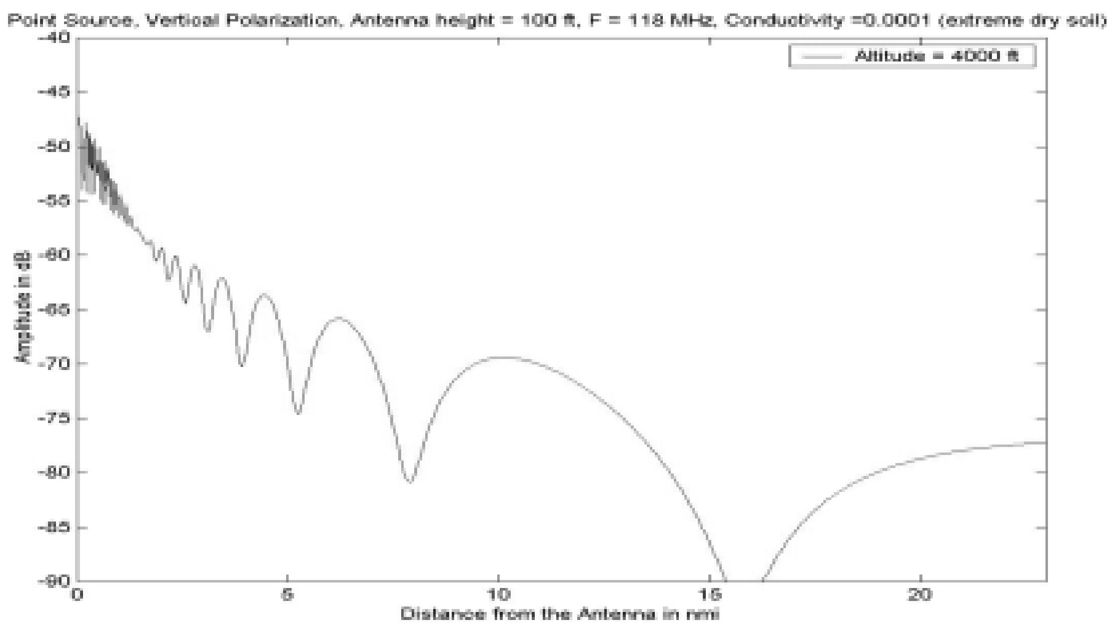


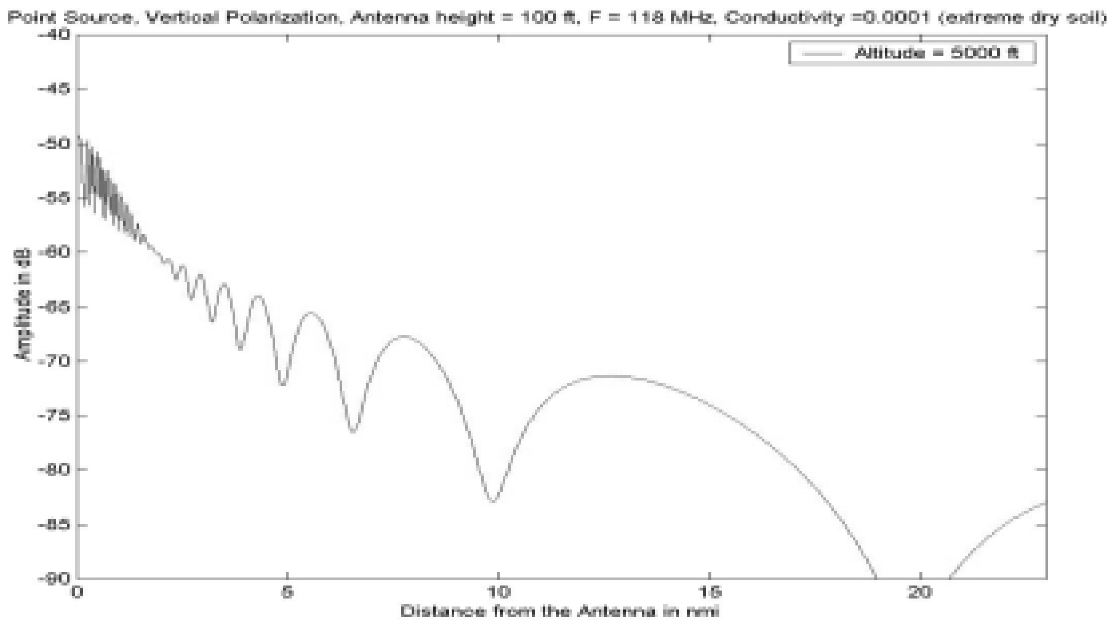
Point Source, Vertical Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 10,000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

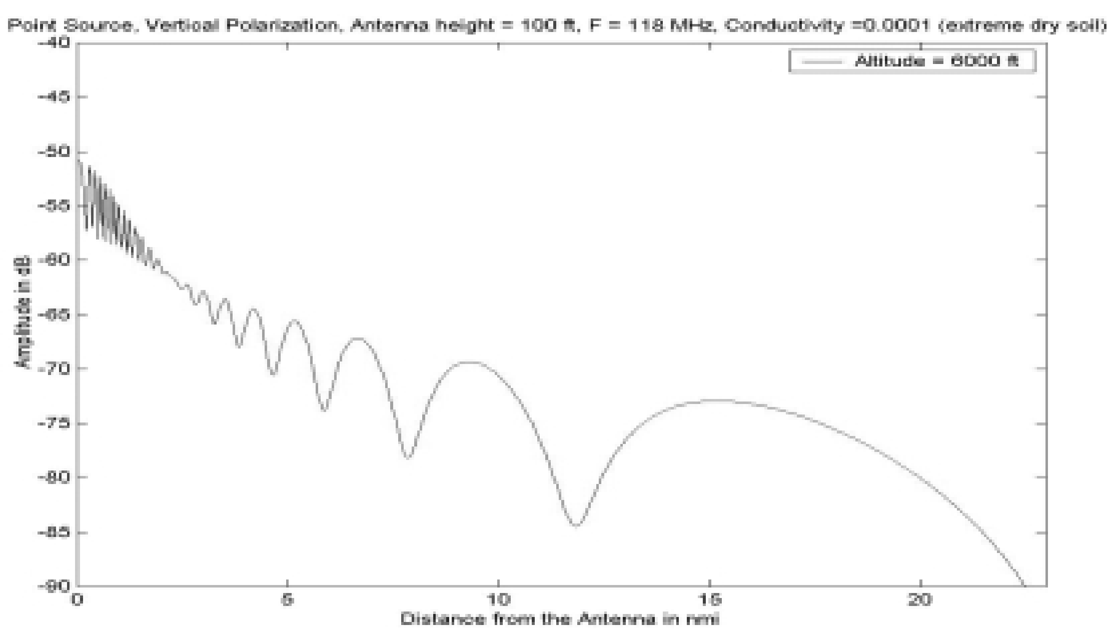


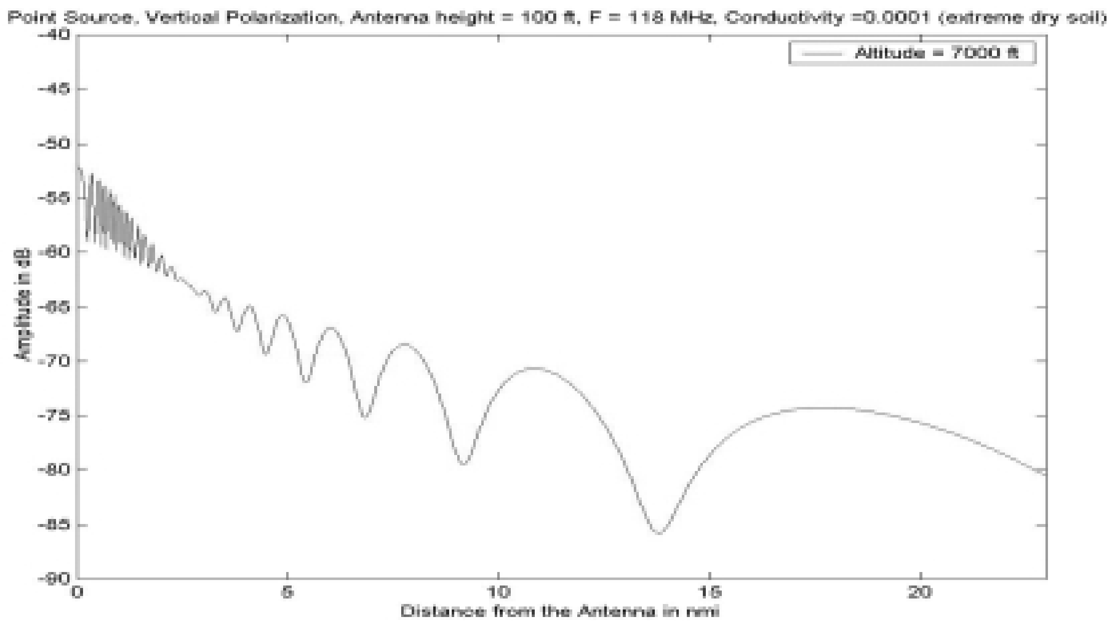
Point Source, Vertical Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 2000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

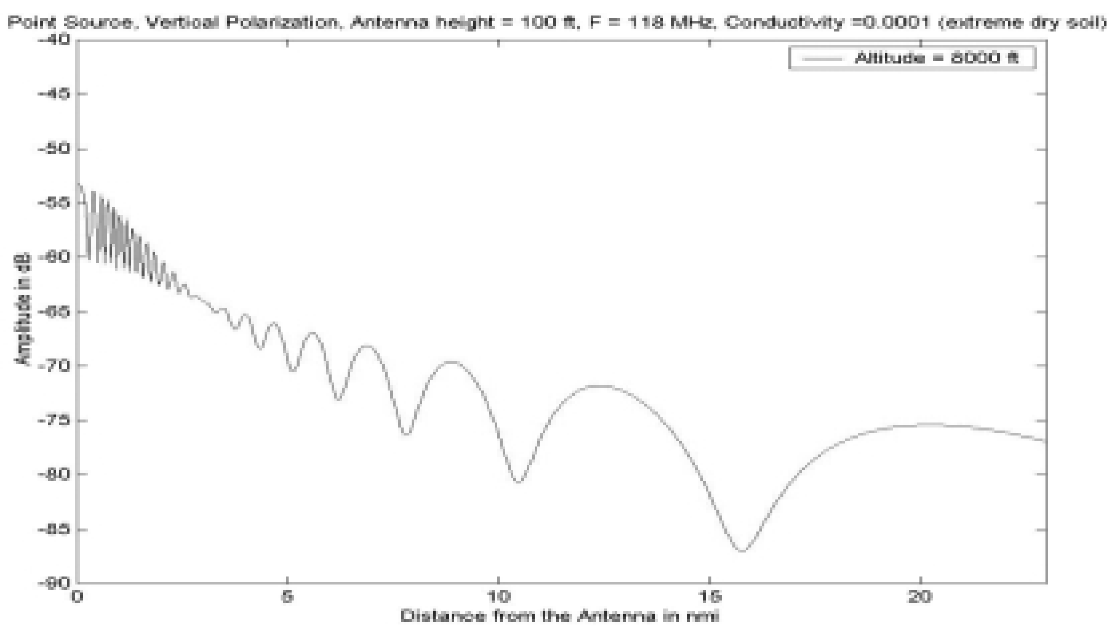

Point Source, Vertical Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 3000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

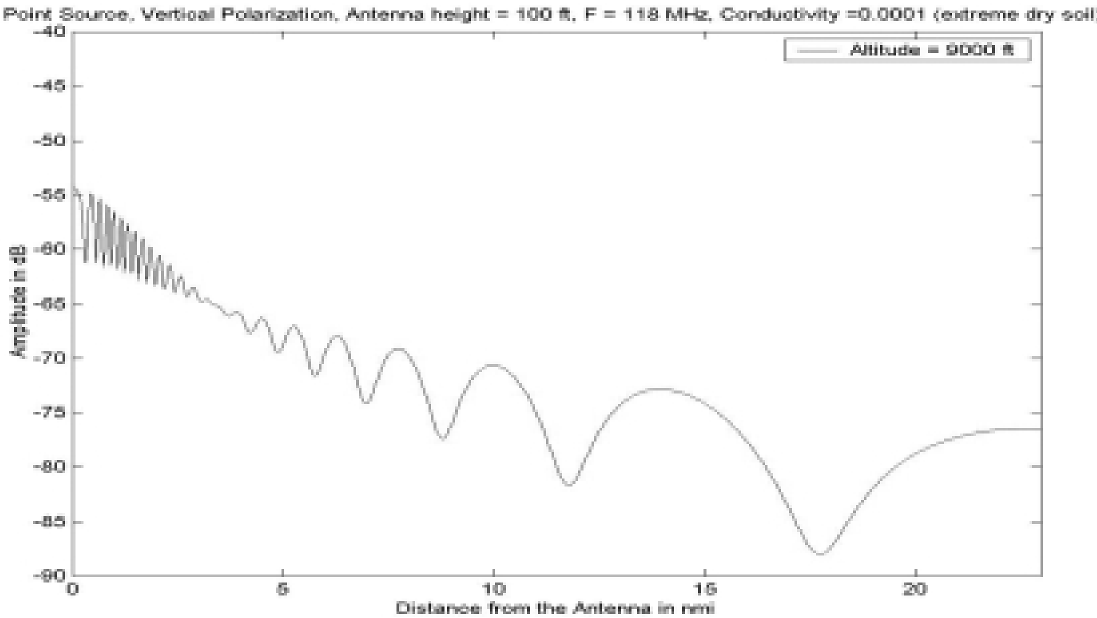

Point Source, Vertical Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 4000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

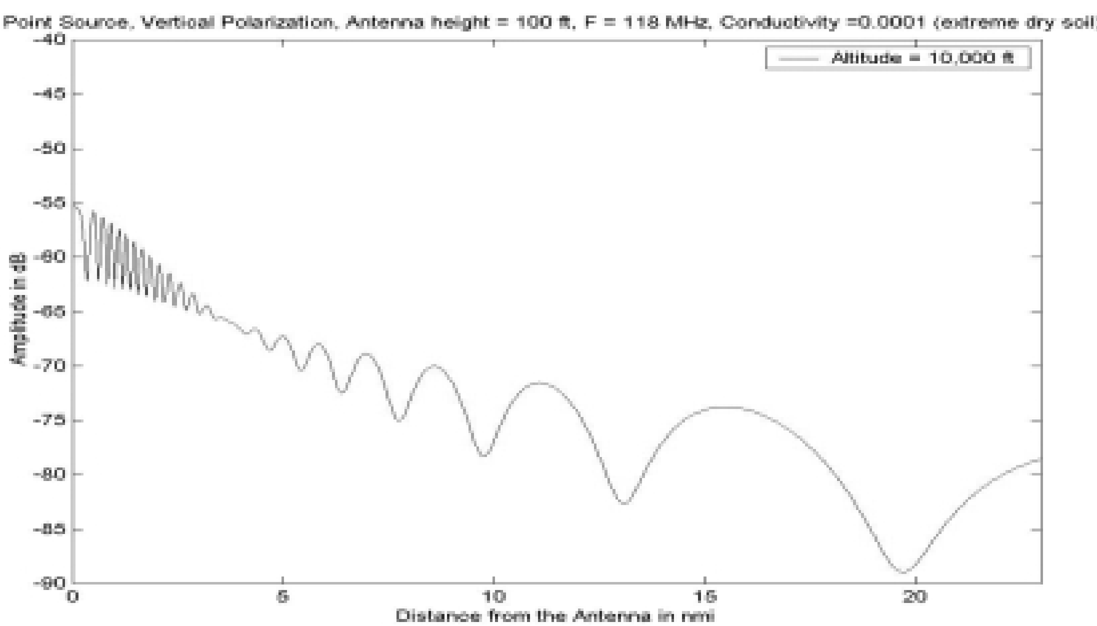

Point Source, Vertical Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 5000 ft
Amplitude in dB
Distance from the Antenna in nmi

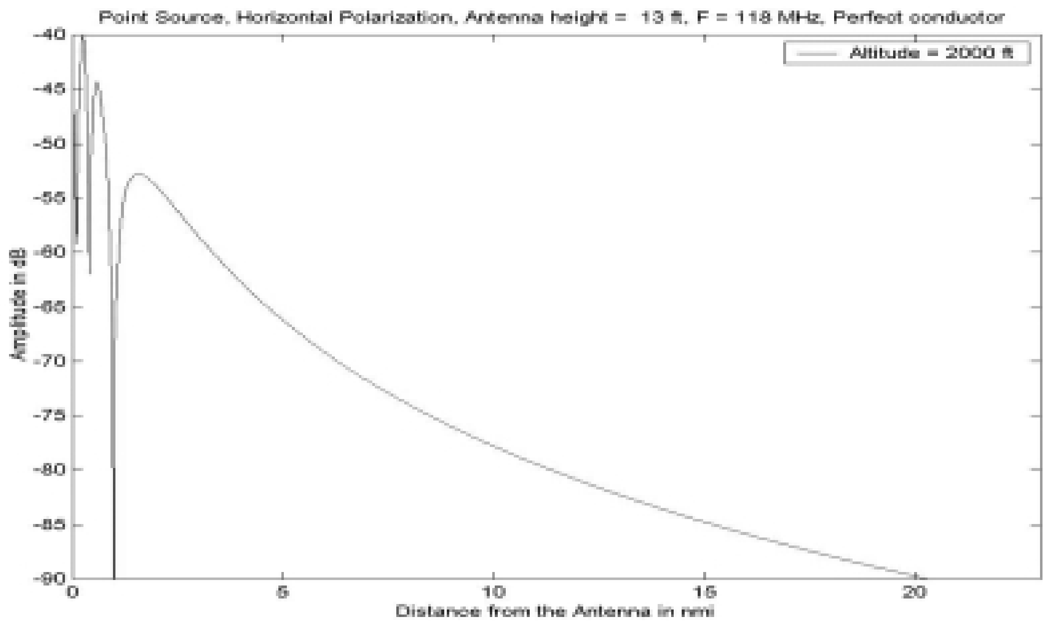

Point Source, Vertical Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 6000 ft
Amplitude in dB
Distance from the Antenna in nmi

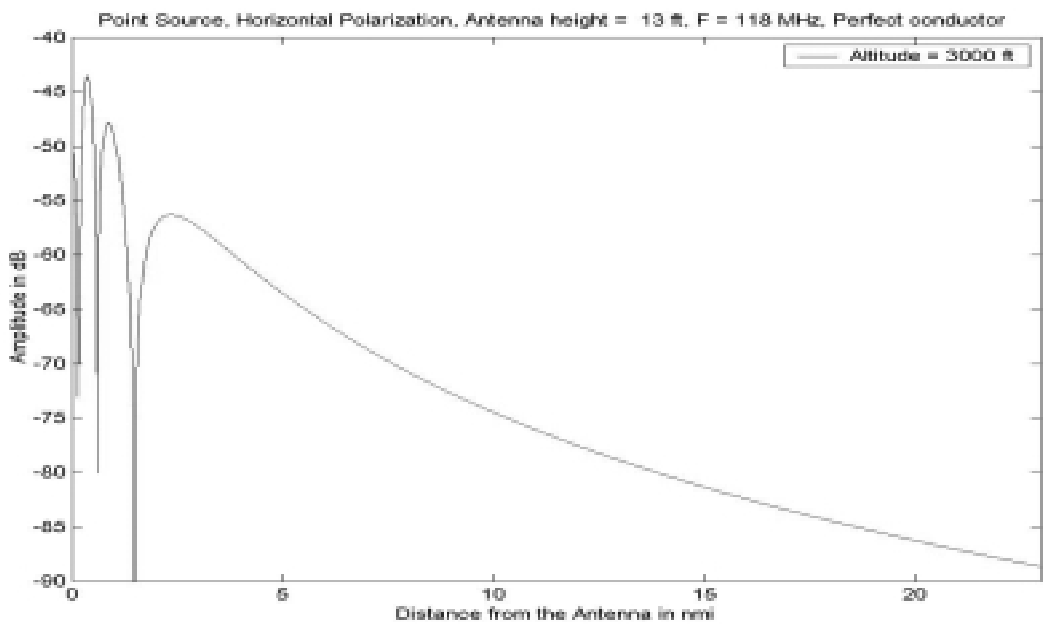

Point Source, Vertical Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 7000 ft
Amplitude in dB
Distance from the Antenna in nmi

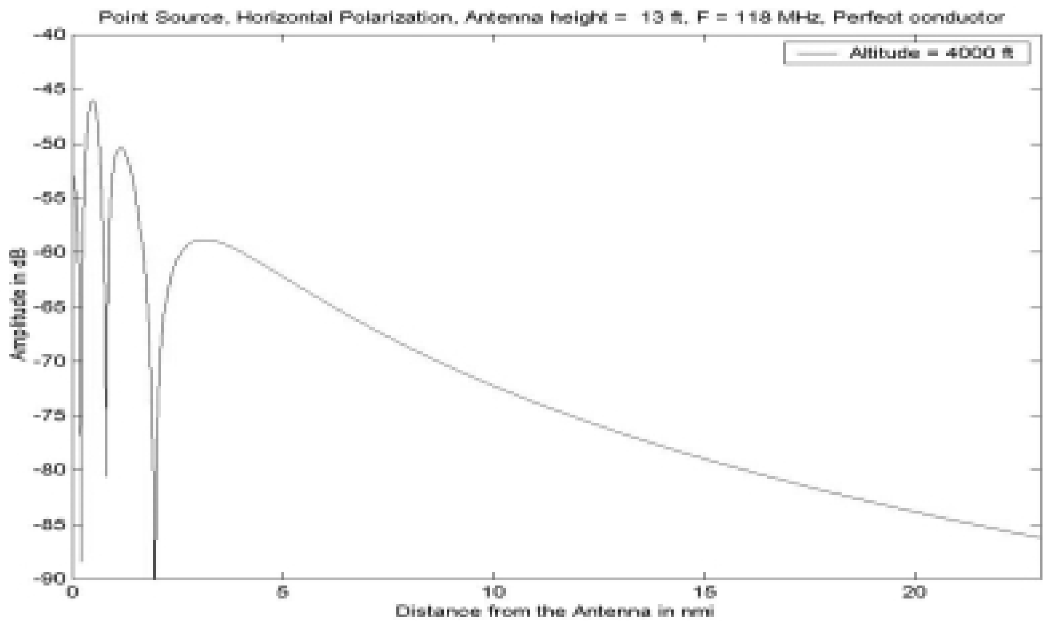

Point Source, Vertical Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 8000 ft
Amplitude in dB
Distance from the Antenna in nmi

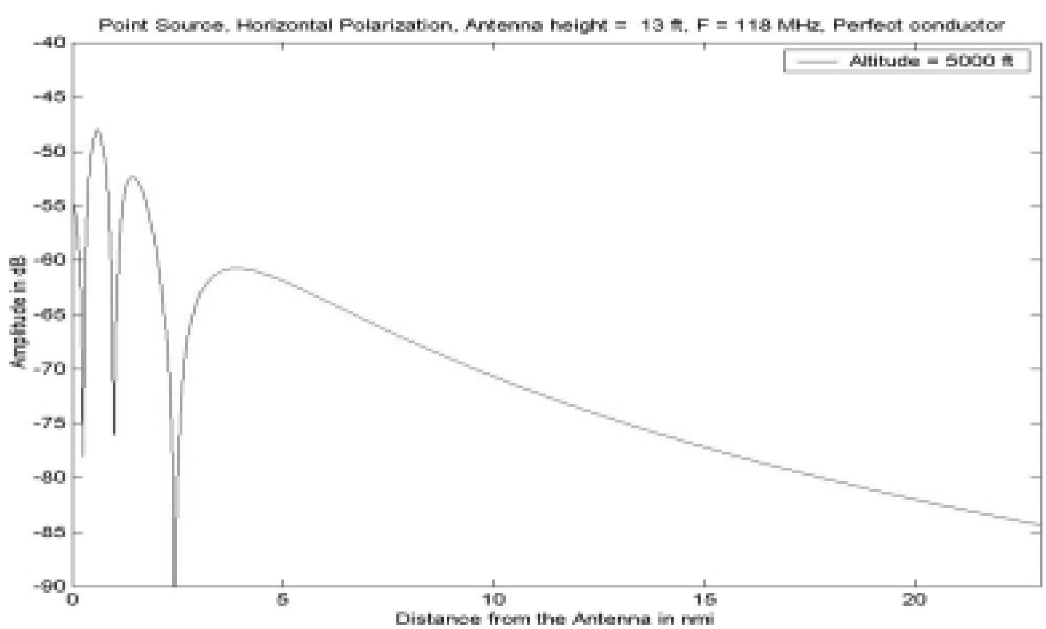

Point Source, Vertical Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 9000 ft
Amplitude in dB
Distance from the Antenna in nmi

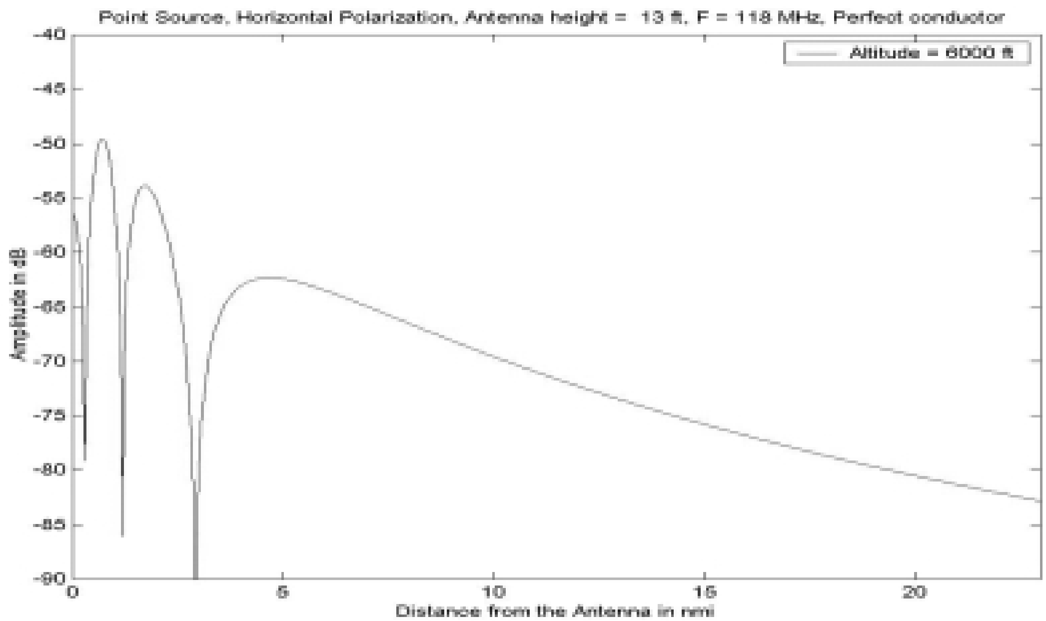

Point Source, Vertical Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 10,000 ft
Amplitude in dB
Distance from the Antenna in nmi

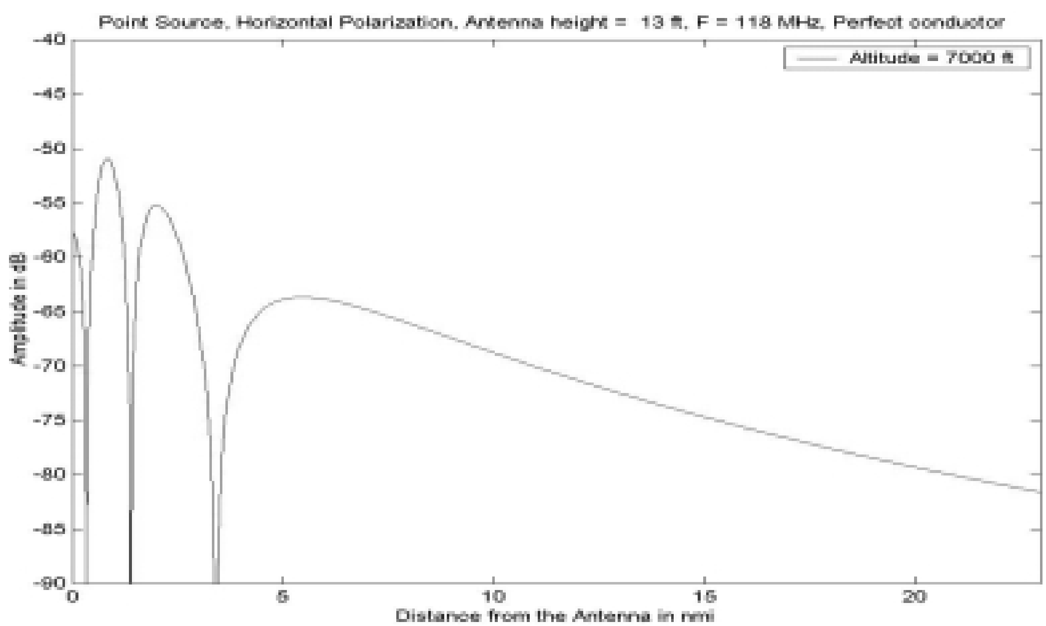

Point Source, Horizontal Polarization, Antenna height = 13 ft, F = 118 MHz, Perfect conductor
Altitude = 2000 ft
Amplitude in dB
Distance from the Antenna in nmi

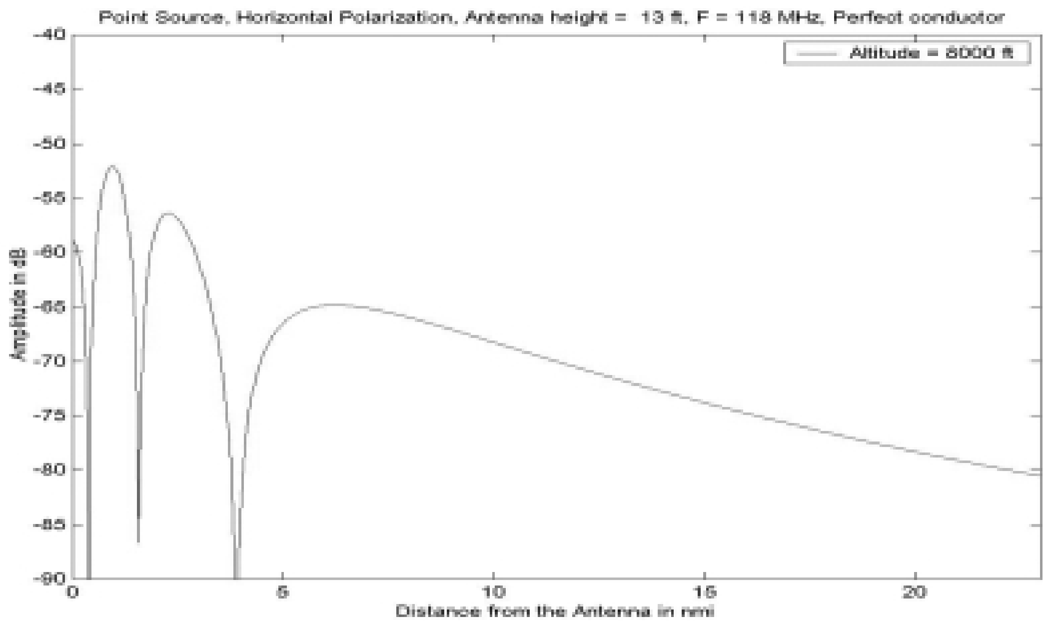

Point Source, Horizontal Polarization, Antenna height = 13 ft, F = 118 MHz, Perfect conductor
Altitude = 3000 ft
Amplitude in dB
Distance from the Antenna in nmi

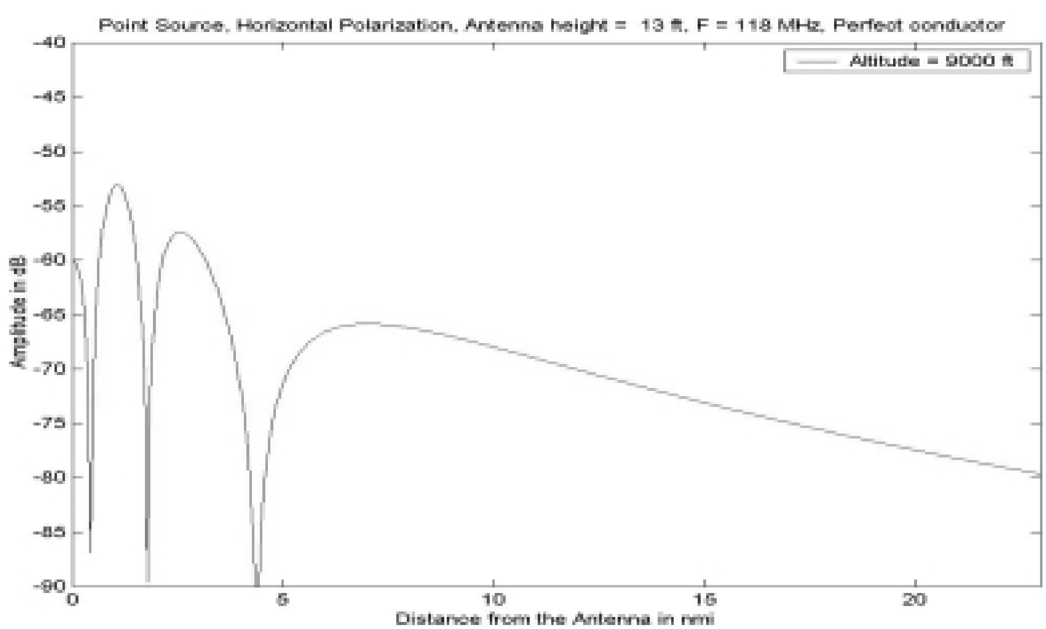

Point Source, Horizontal Polarization, Antenna height = 13 ft, F = 118 MHz, Perfect conductor
Altitude = 4000 ft
Amplitude in dB
Distance from the Antenna in nmi

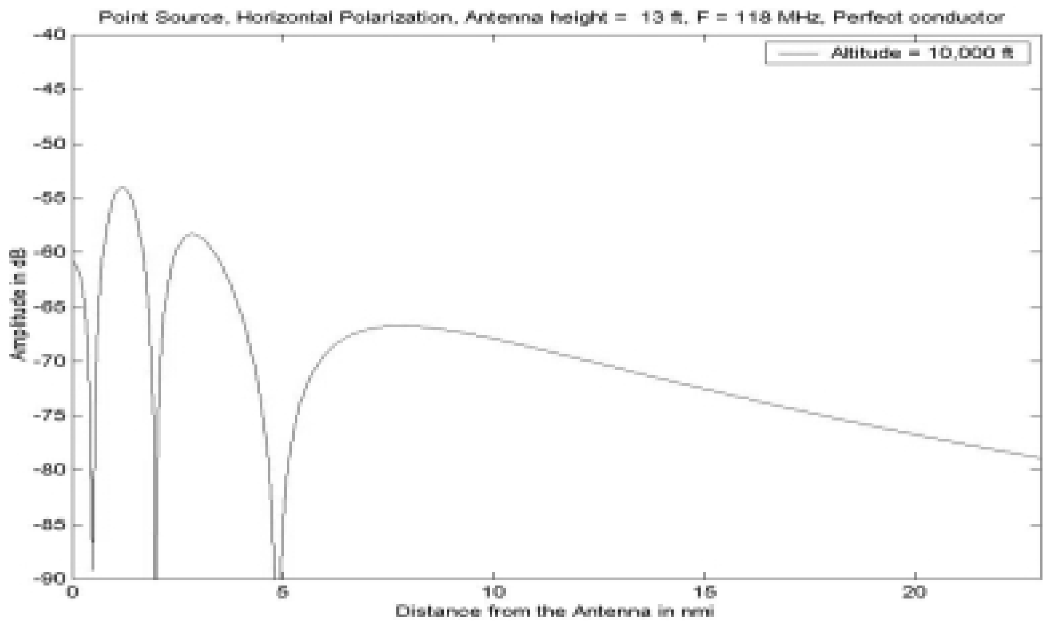

Point Source, Horizontal Polarization, Antenna height = 13 ft, F = 118 MHz, Perfect conductor
Altitude = 5000 ft
Amplitude in dB
Distance from the Antenna in nmi

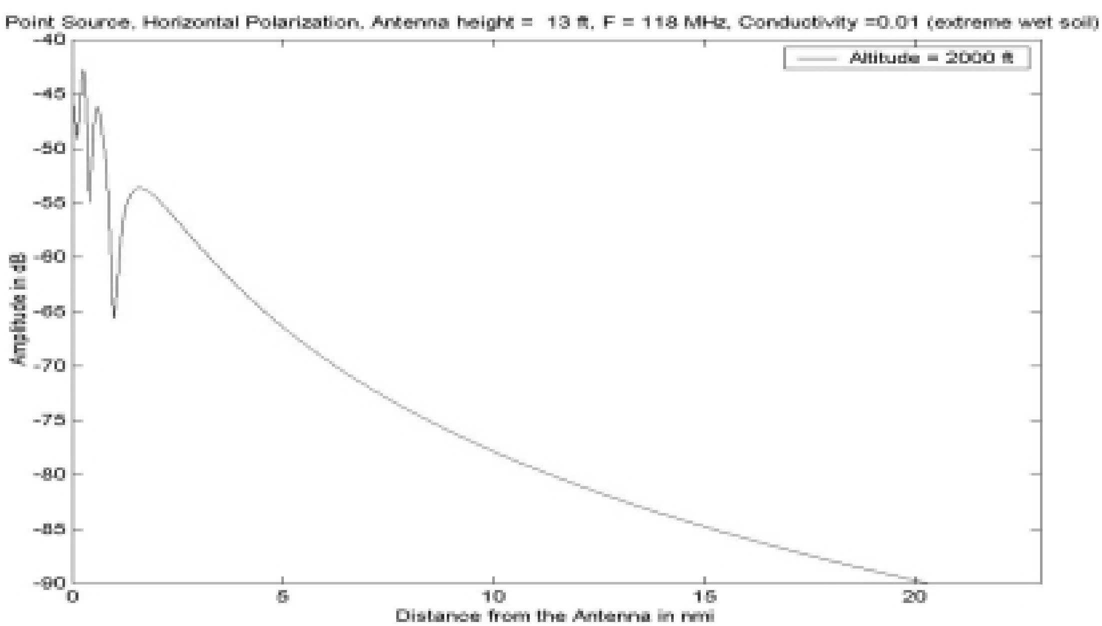

Point Source, Horizontal Polarization, Antenna height = 13 ft, F = 118 MHz, Perfect conductor
Altitude = 6000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

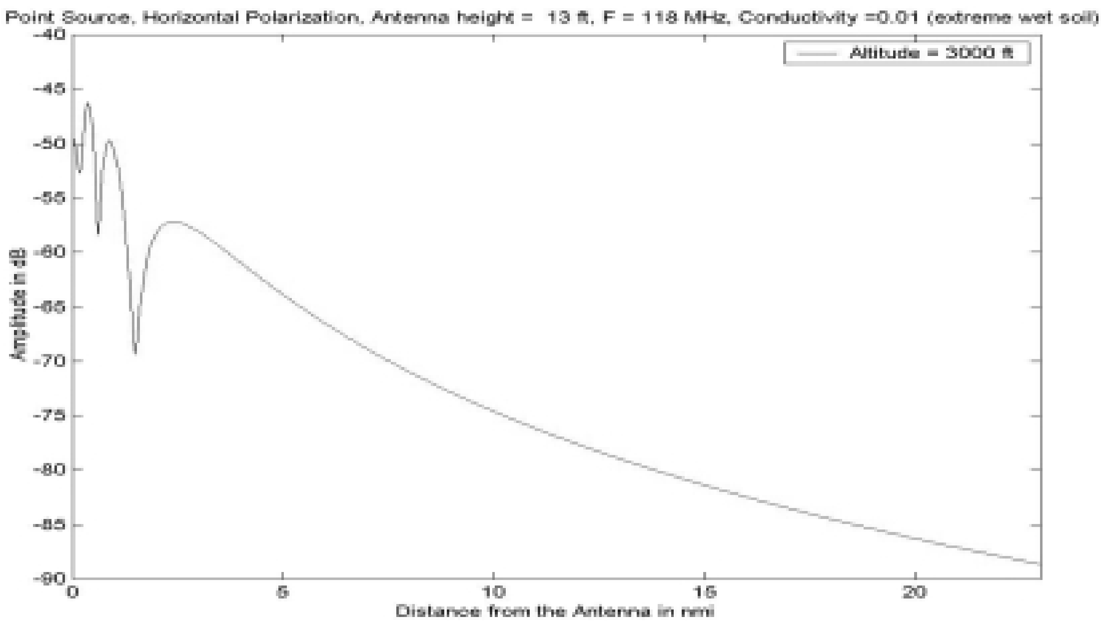

Point Source, Horizontal Polarization, Antenna height = 13 ft, F = 118 MHz, Perfect conductor
Altitude = 7000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20


Point Source, Horizontal Polarization, Antenna height = 13 ft, F = 118 MHz, Perfect conductor
Altitude = 8000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

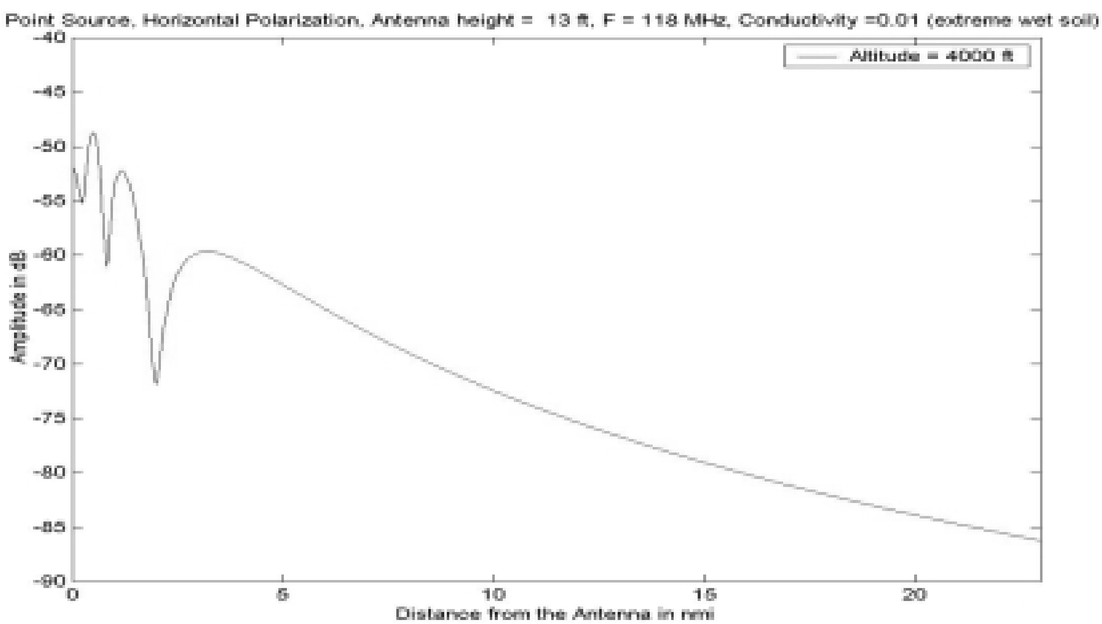

Point Source, Horizontal Polarization, Antenna height = 13 ft, F = 118 MHz, Perfect conductor
Altitude = 9000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20


Point Source, Horizontal Polarization, Antenna height = 13 ft, F = 118 MHz, Perfect conductor
Altitude = 10,000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

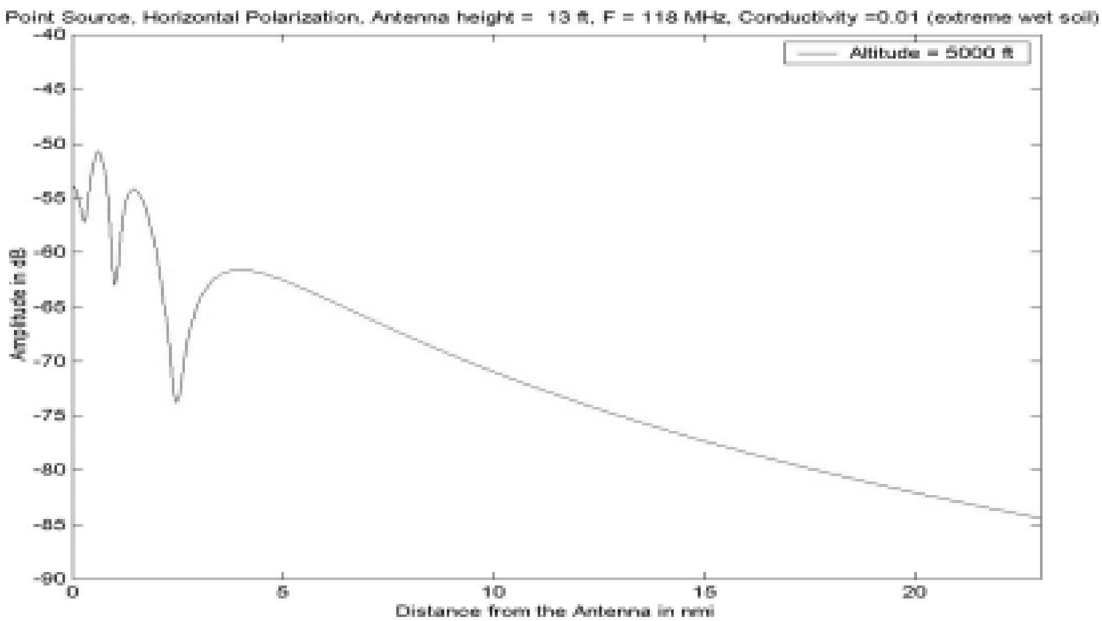

Point Source, Horizontal Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 2000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

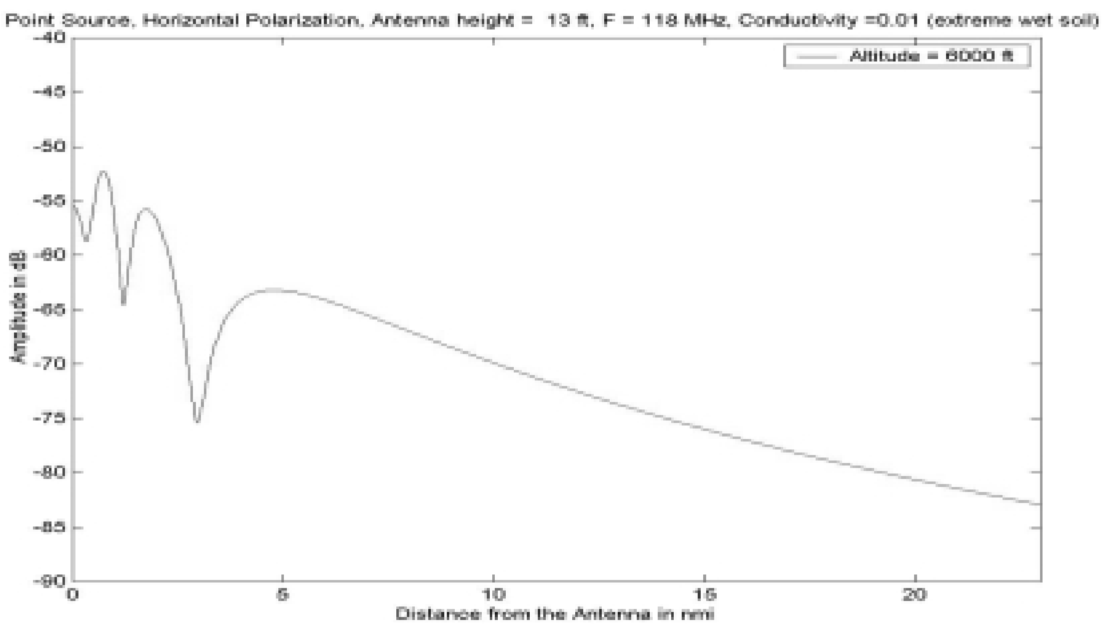


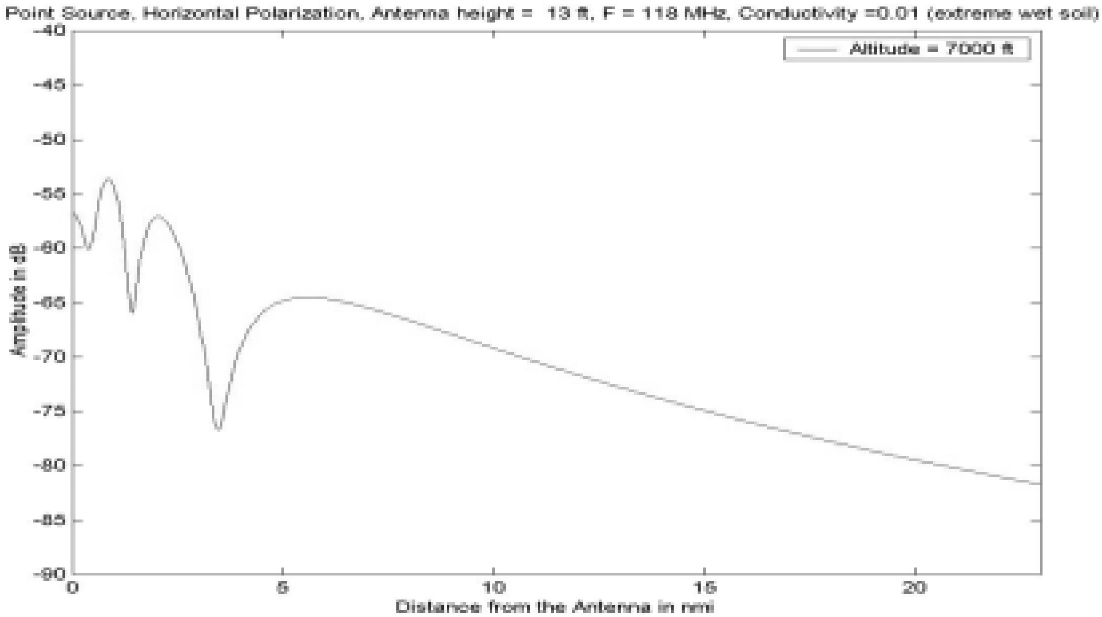
Point Source, Horizontal Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 3000 ft
Amplitude in dB
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20
Distance from the Antenna in nmi



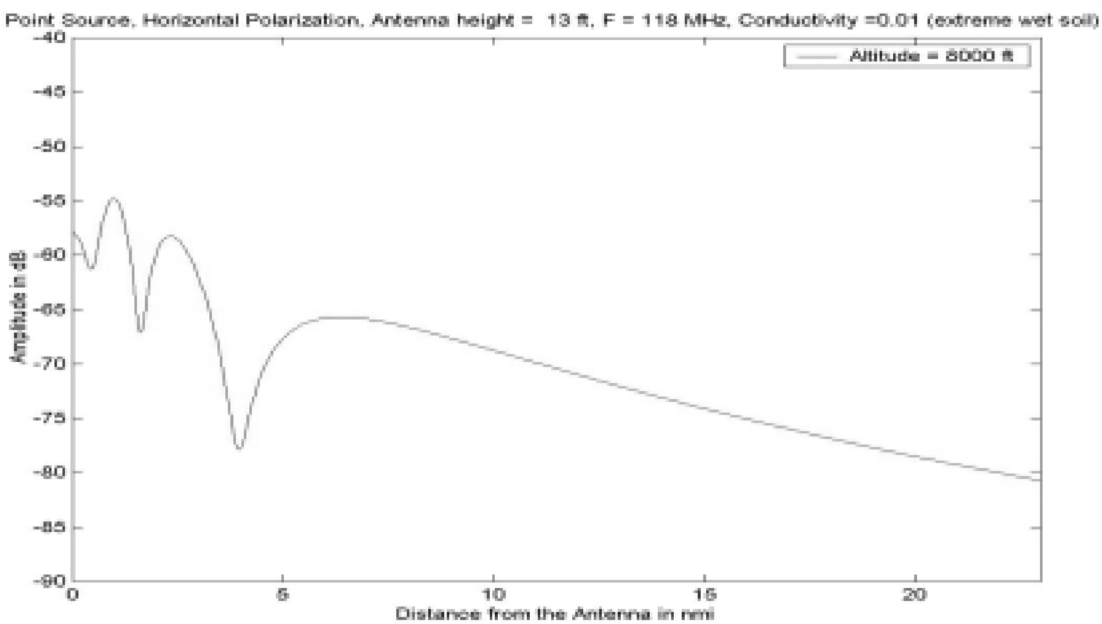
Point Source, Horizontal Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 4000 ft
Amplitude in dB
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20
Distance from the Antenna in nmi


Point Source, Horizontal Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 5000 ft
Amplitude in dB
Distance from the Antenna in nmi

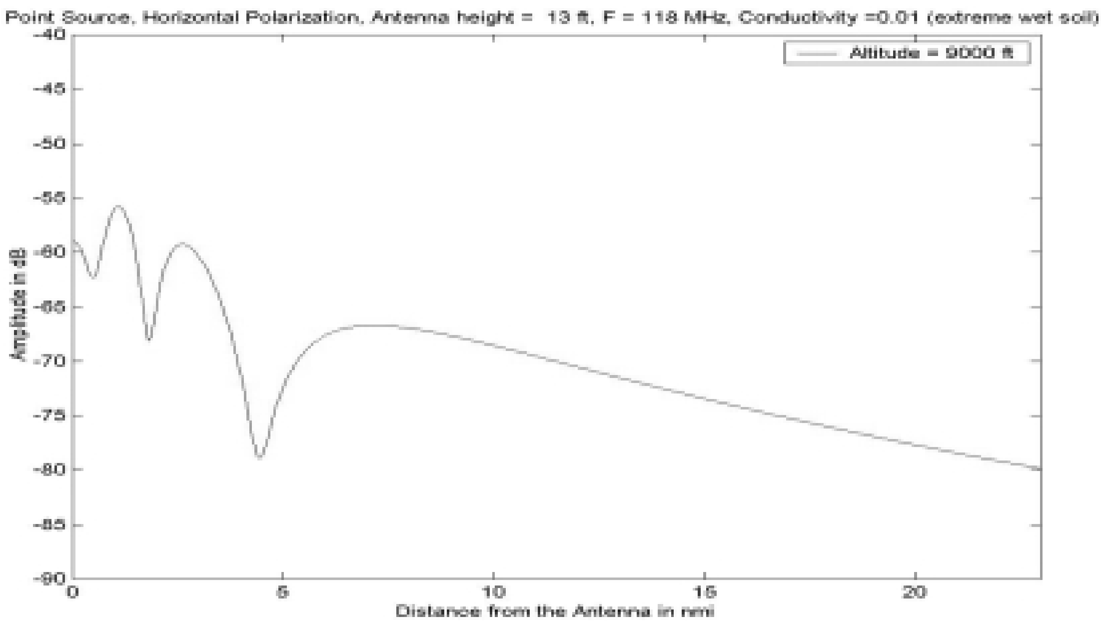

Point Source, Horizontal Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 6000 ft
Amplitude in dB
Distance from the Antenna in nmi

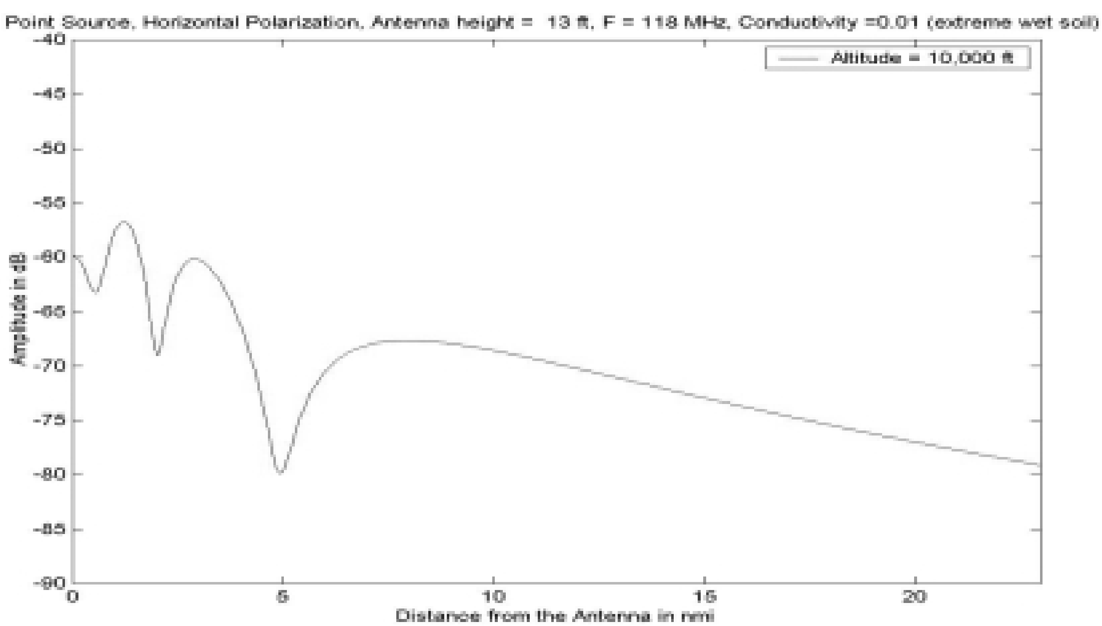


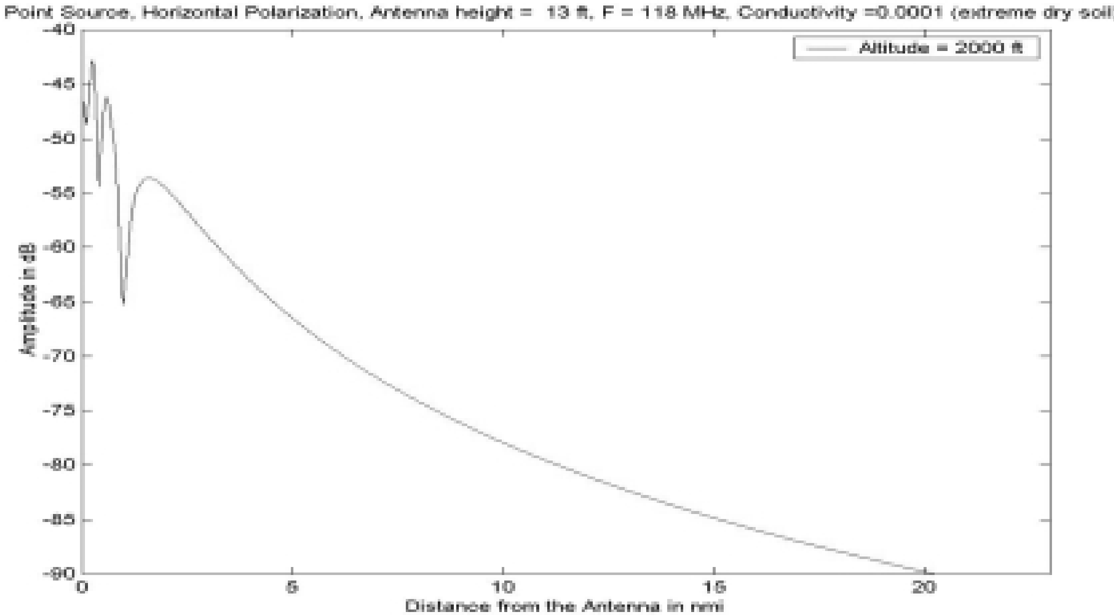
Point Source, Horizontal Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 7000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

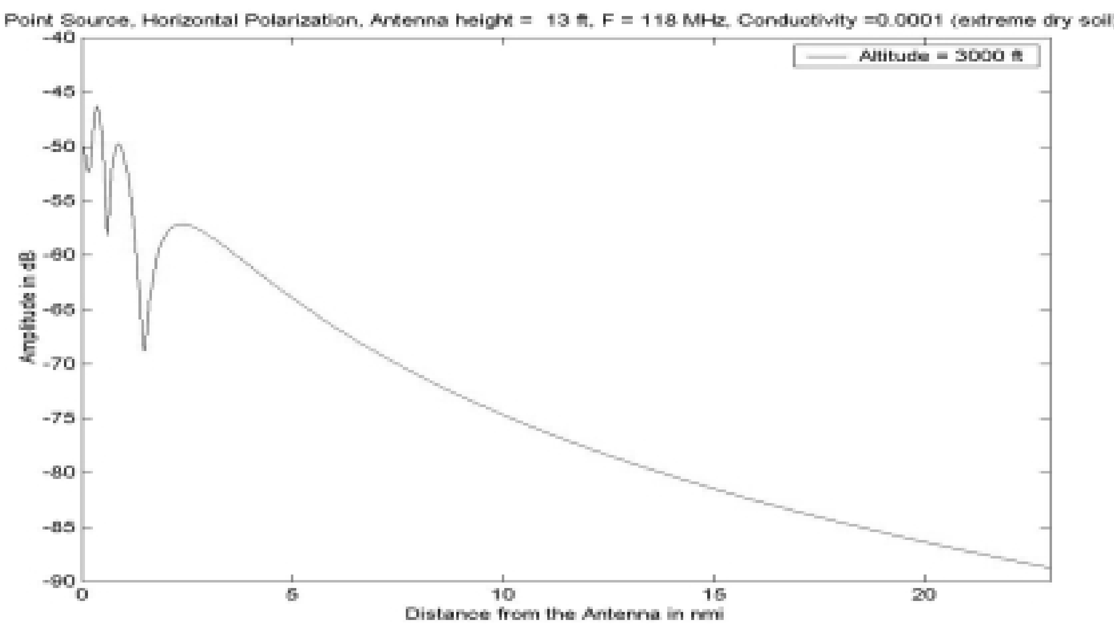


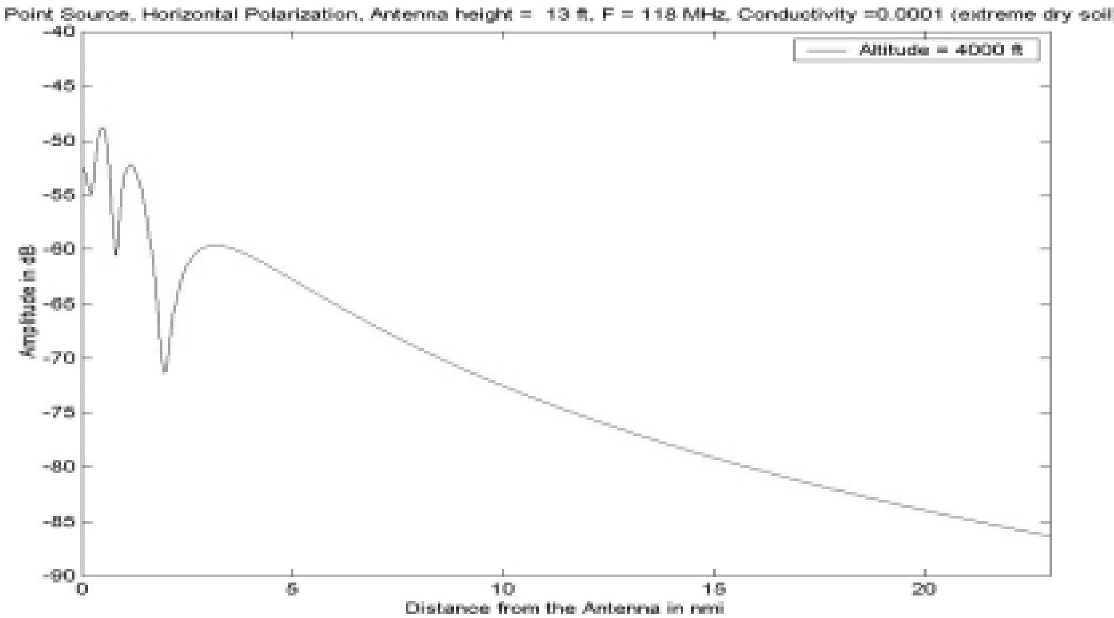
Point Source, Horizontal Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 8000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

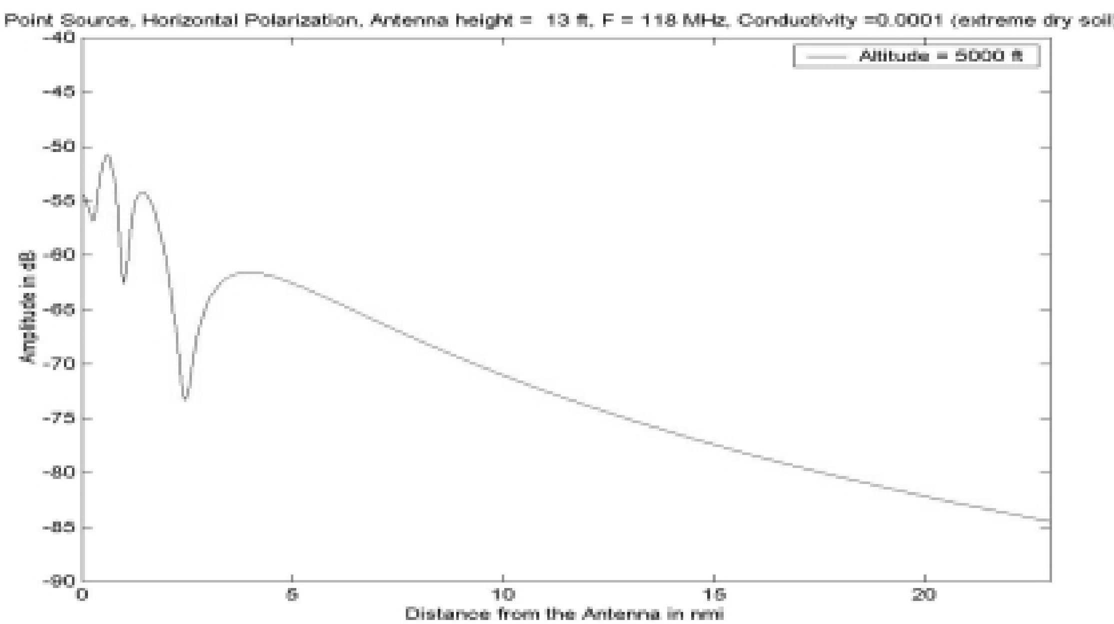

Point Source, Horizontal Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 9000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

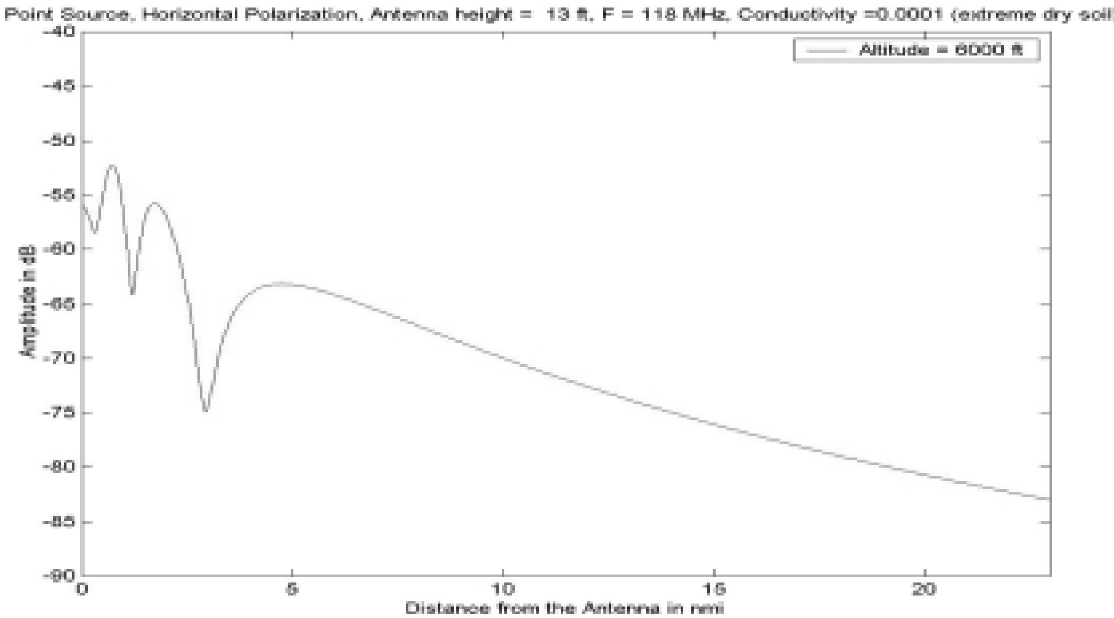

Point Source, Horizontal Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 10,000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

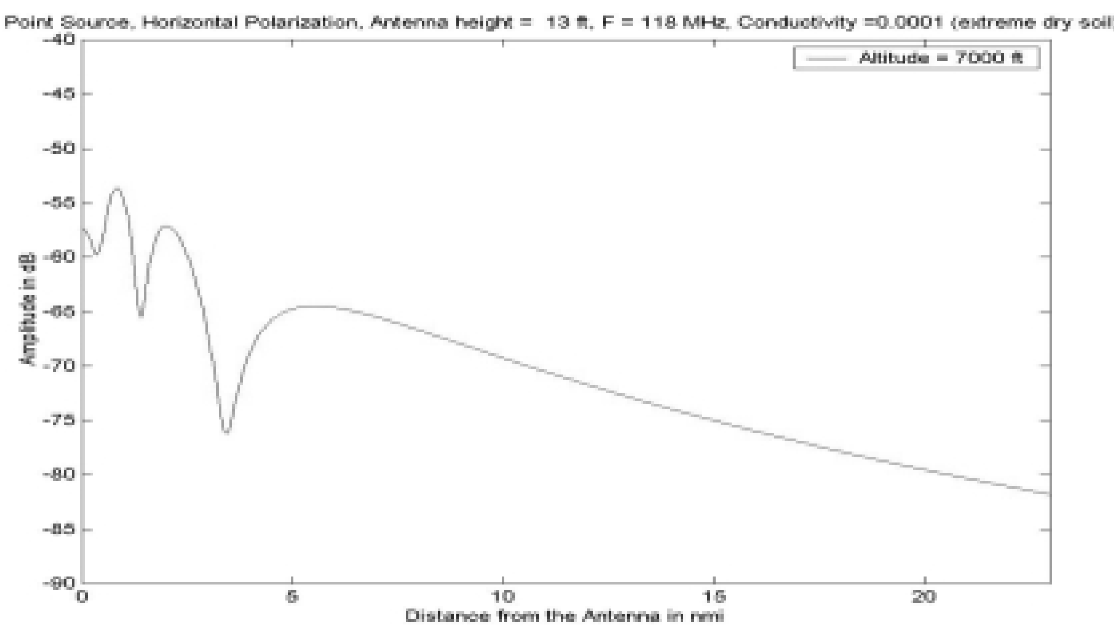

Point Source, Horizontal Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 2000 ft
Amplitude in dB
Distance from the Antenna in nmi

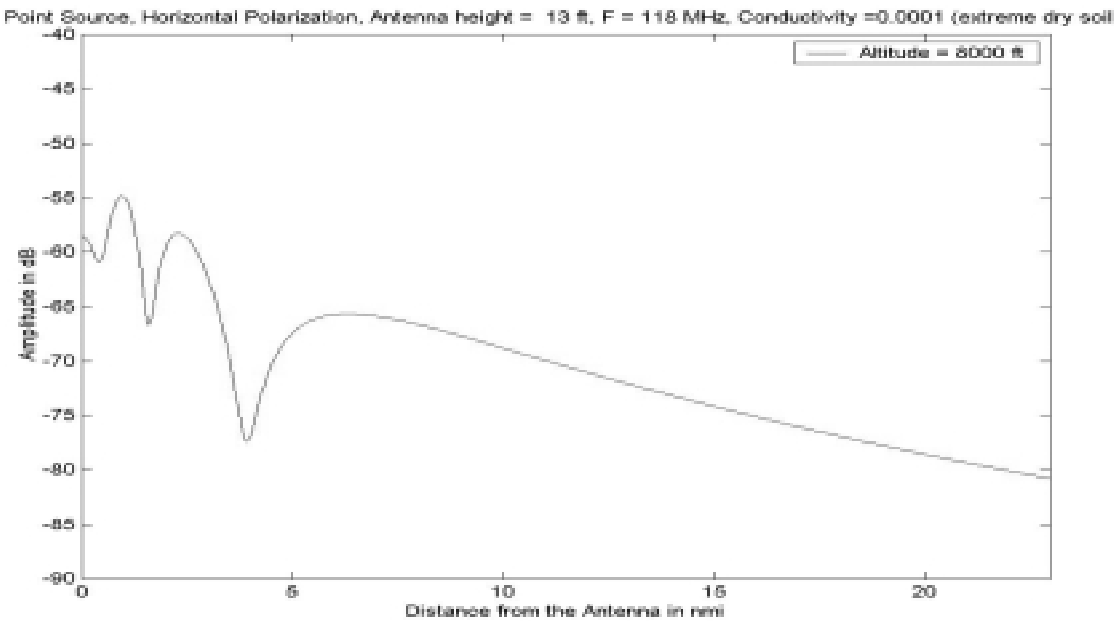

Point Source, Horizontal Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 3000 ft
Amplitude in dB
Distance from the Antenna in nmi

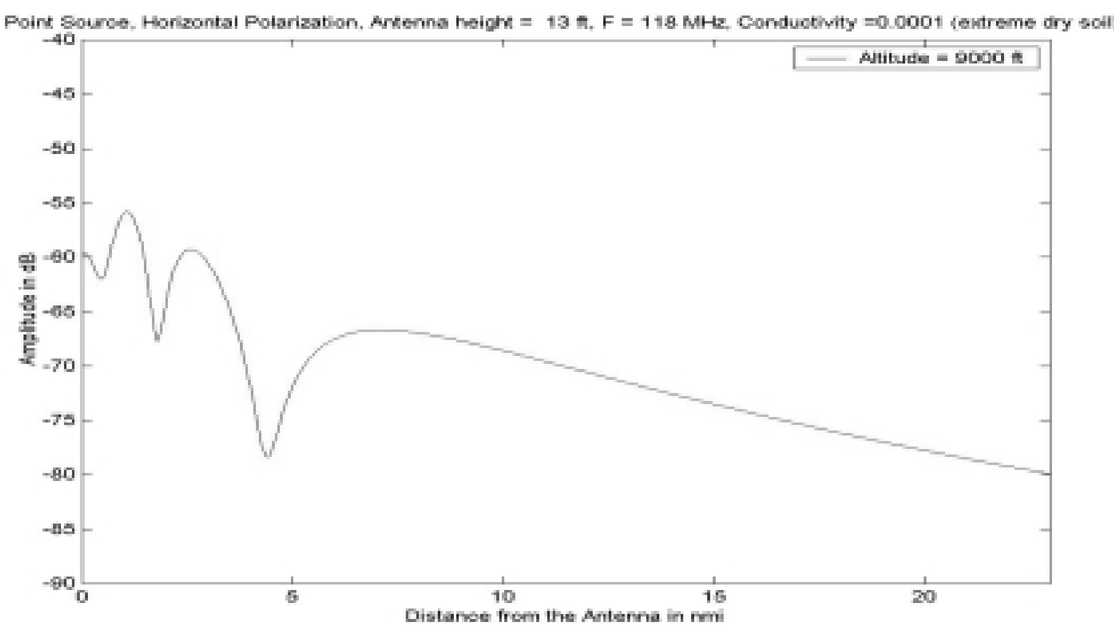

Point Source, Horizontal Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 4000 ft
Amplitude in dB
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20
Distance from the Antenna in nmi

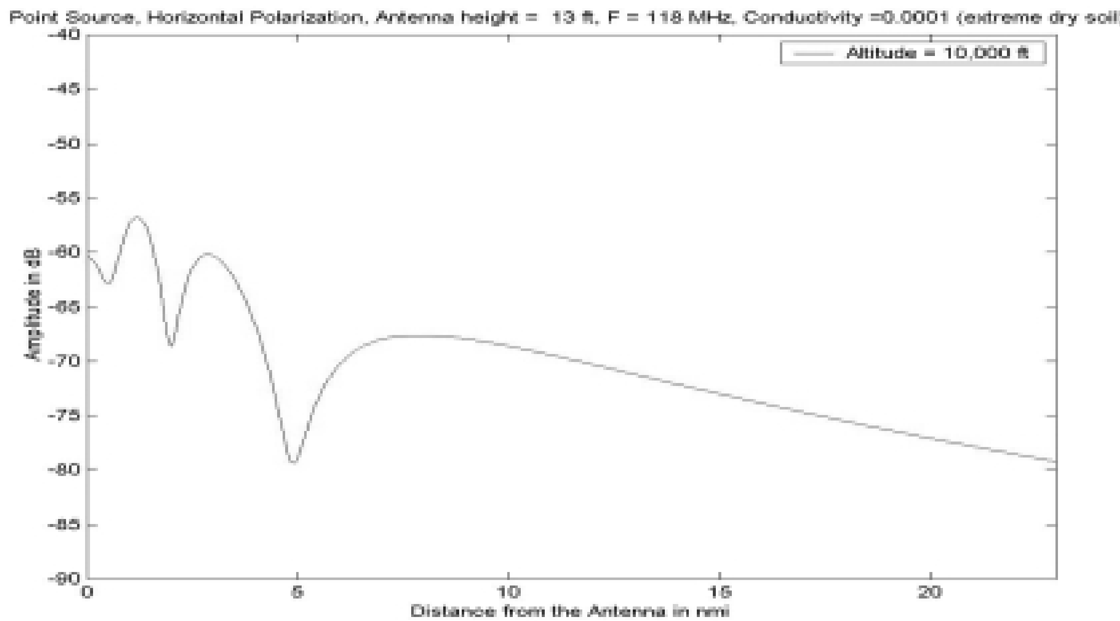

Point Source, Horizontal Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 5000 ft
Amplitude in dB
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20
Distance from the Antenna in nmi

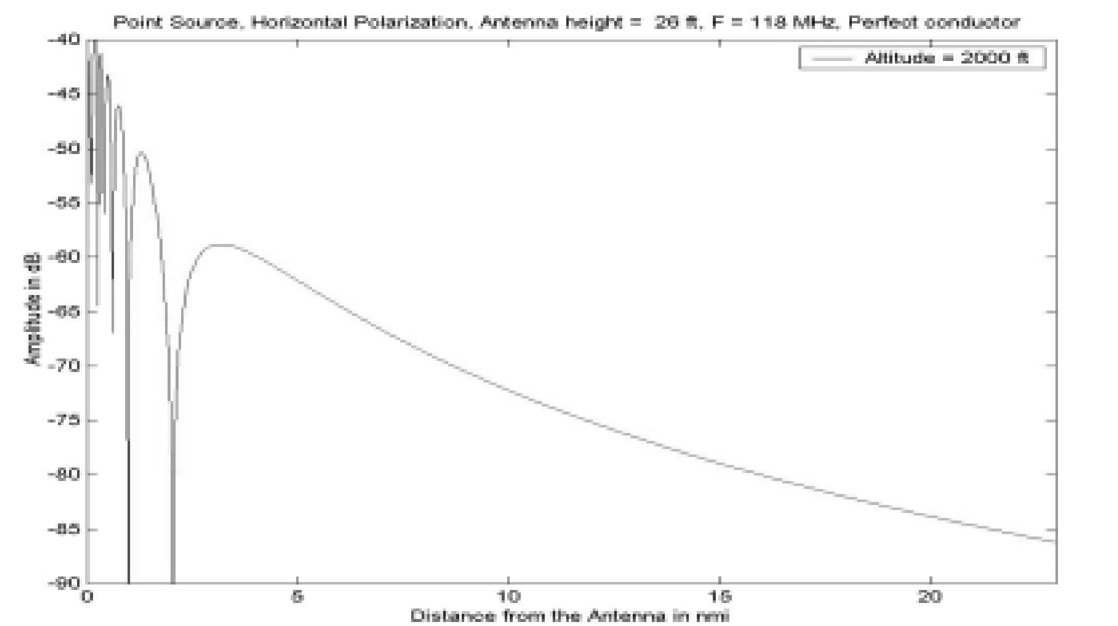

Point Source, Horizontal Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 6000 ft
Amplitude in dB
Distance from the Antenna in nmi

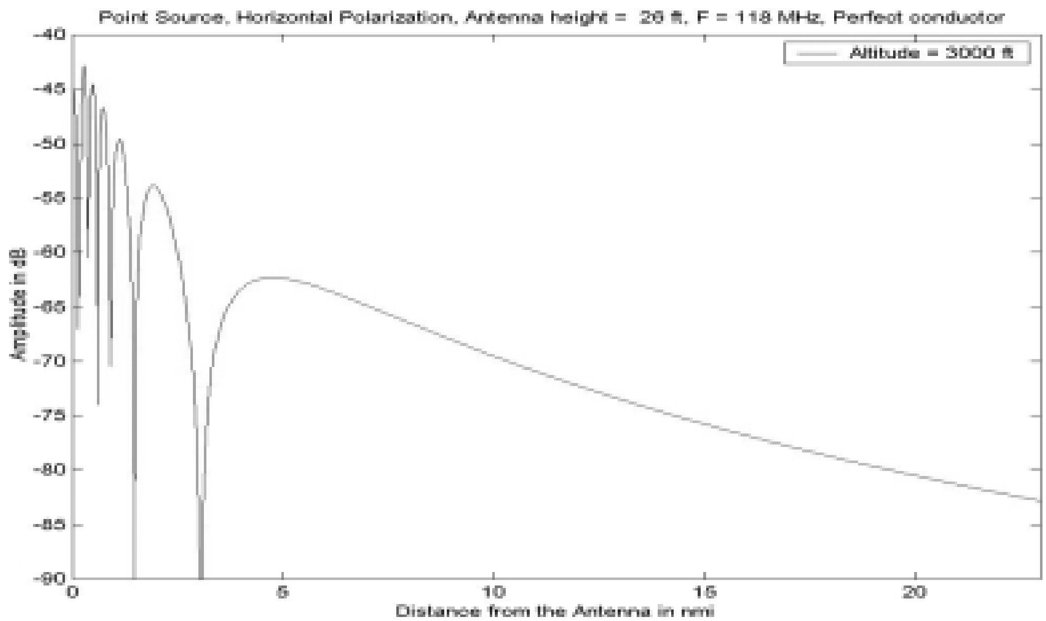

Point Source, Horizontal Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 7000 ft
Amplitude in dB
Distance from the Antenna in nmi

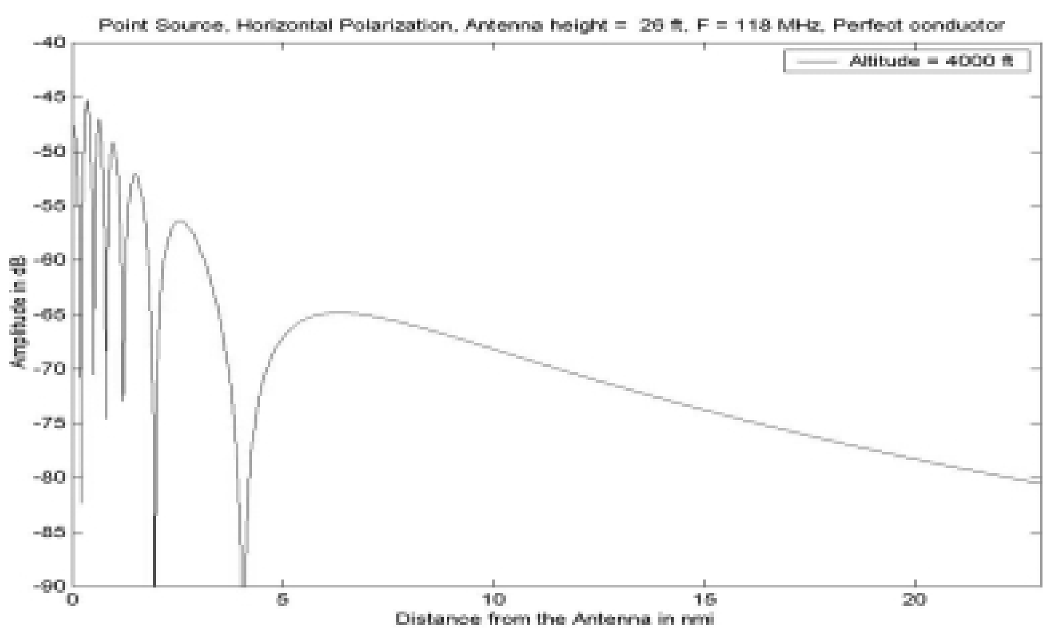

Point Source, Horizontal Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 8000 ft
Amplitude in dB
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20
Distance from the Antenna in nmi

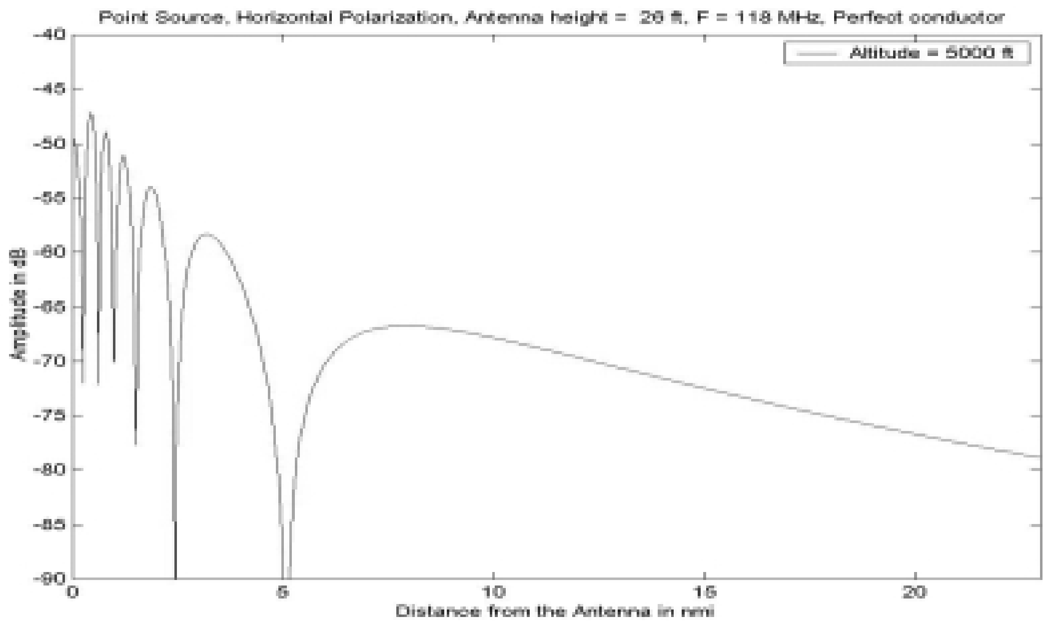

Point Source, Horizontal Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 9000 ft
Amplitude in dB
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20
Distance from the Antenna in nmi


Point Source, Horizontal Polarization, Antenna height = 13 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 10,000 ft
Amplitude in dB
Distance from the Antenna in nmi

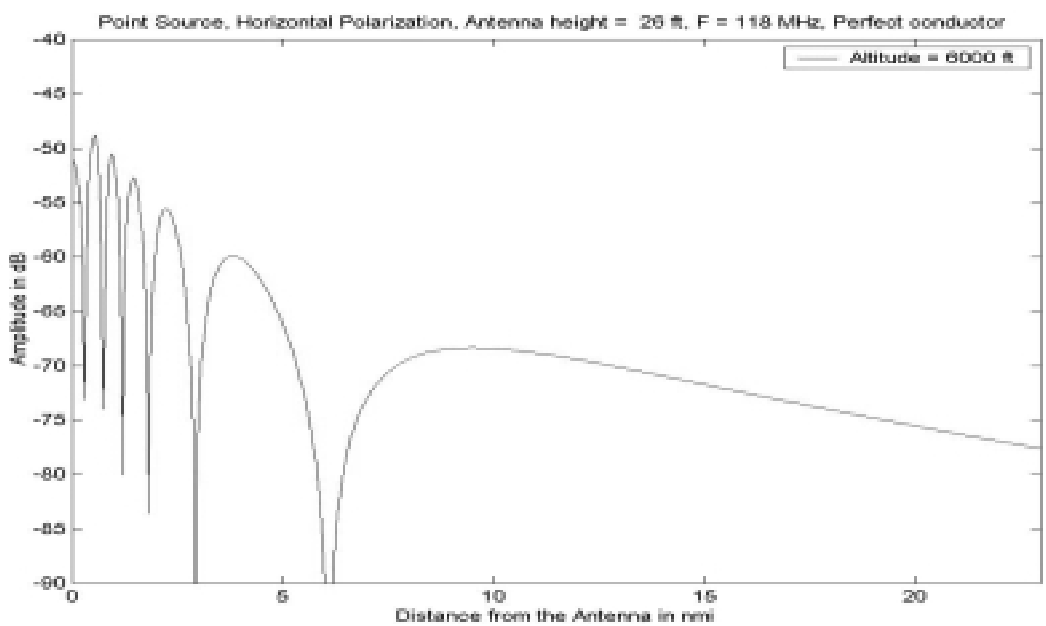

Point Source, Horizontal Polarization, Antenna height = 26 ft, F = 118 MHz, Perfect conductor
Altitude = 2000 ft
Amplitude in dB
Distance from the Antenna in nmi


Point Source, Horizontal Polarization, Antenna height = 26 ft, F = 118 MHz, Perfect conductor
Altitude = 3000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

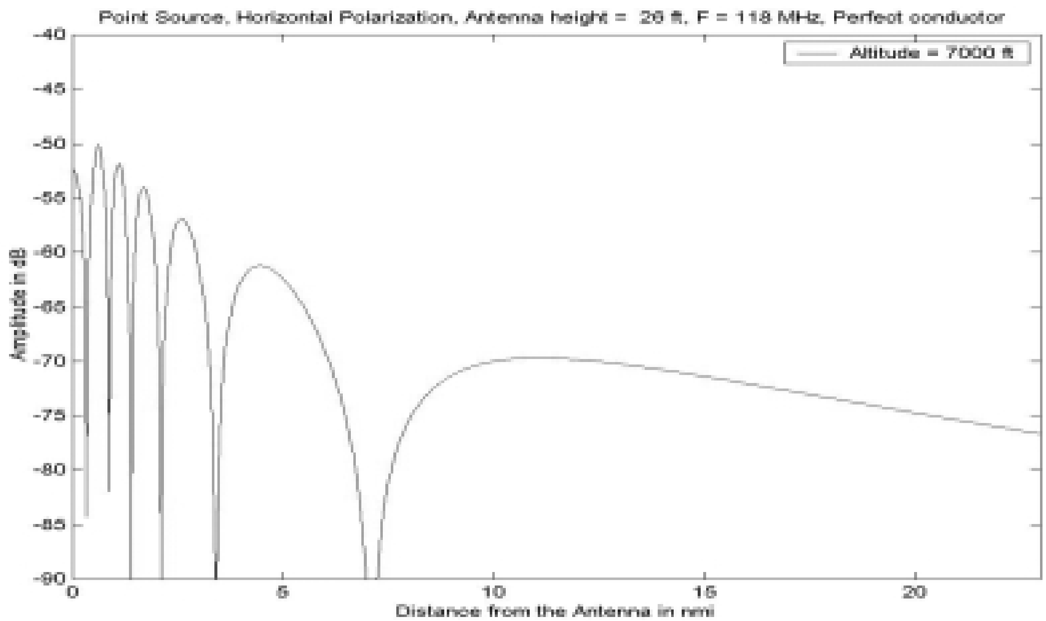

Point Source, Horizontal Polarization, Antenna height = 26 ft, F = 118 MHz, Perfect conductor
Altitude = 4000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

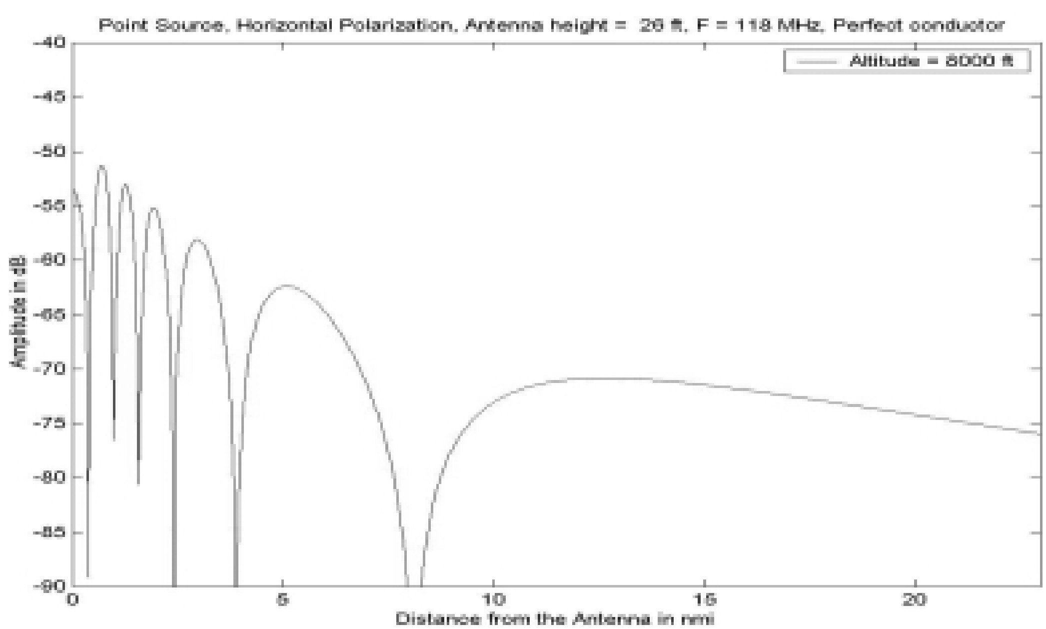


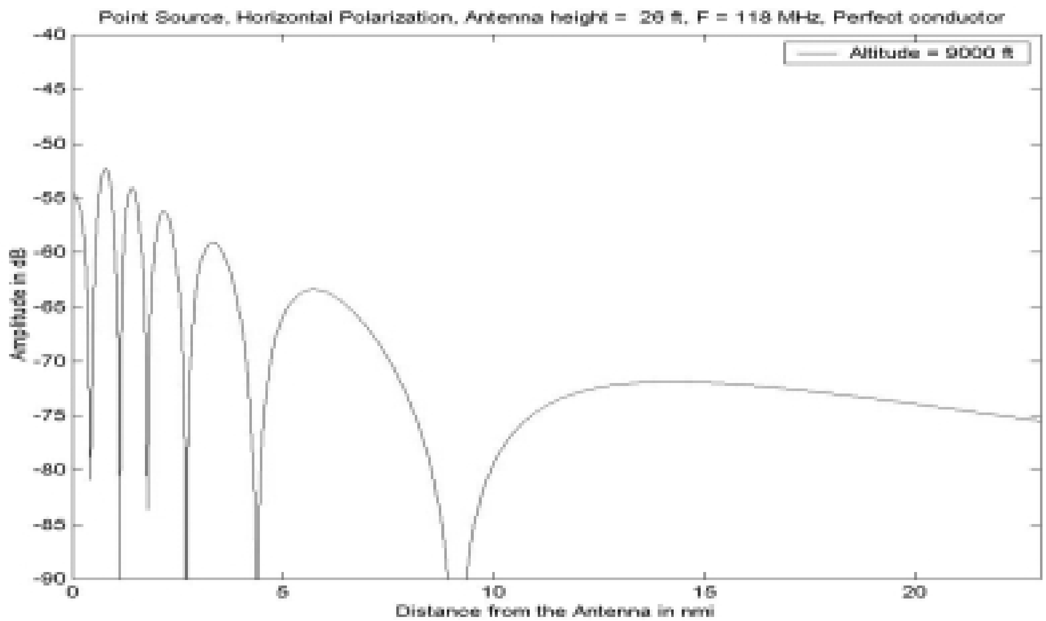
Point Source, Horizontal Polarization, Antenna height = 26 ft, F = 118 MHz, Perfect conductor
Altitude = 5000 ft
Amplitude in dB
Distance from the Antenna in nmi

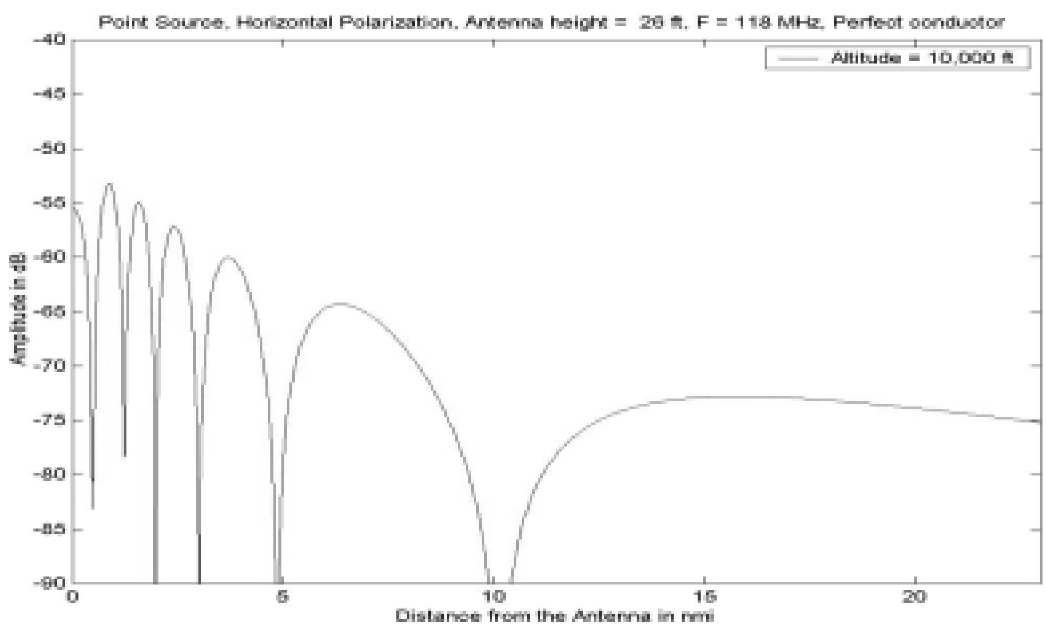


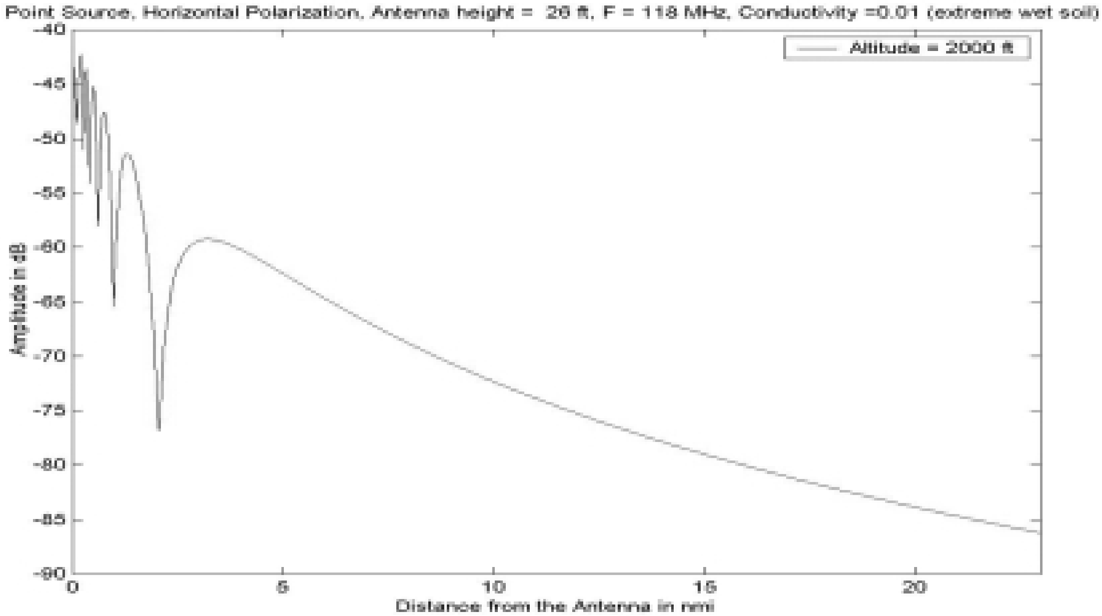
Point Source, Horizontal Polarization, Antenna height = 26 ft, F = 118 MHz, Perfect conductor
Altitude = 6000 ft
Amplitude in dB
Distance from the Antenna in nmi

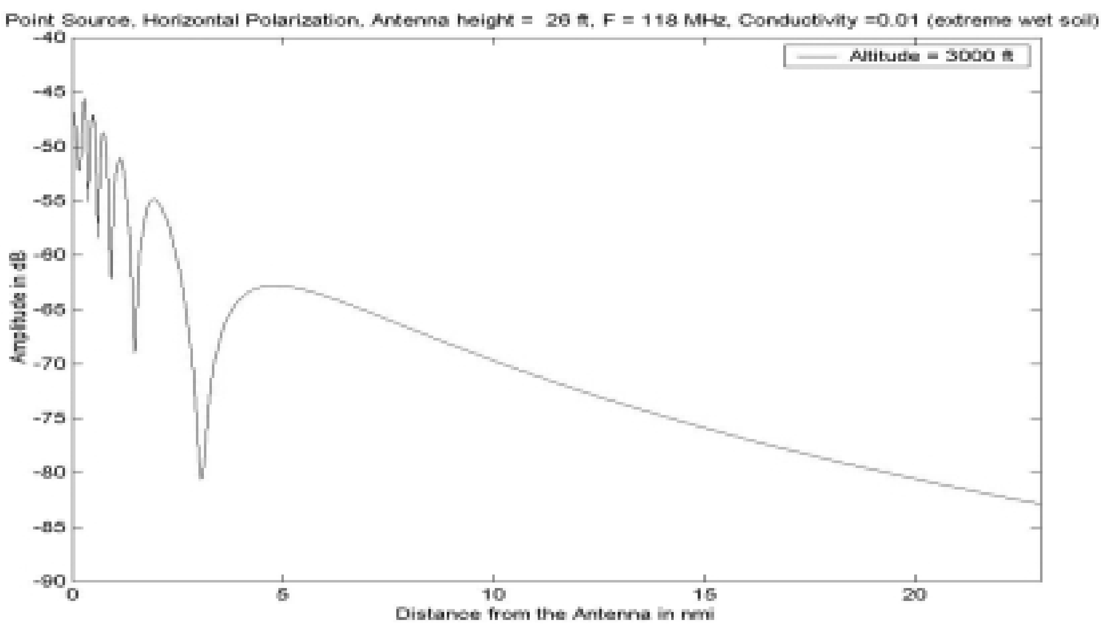

Point Source, Horizontal Polarization, Antenna height = 26 ft, F = 118 MHz, Perfect conductor
Altitude = 7000 ft
Amplitude in dB
Distance from the Antenna in nmi

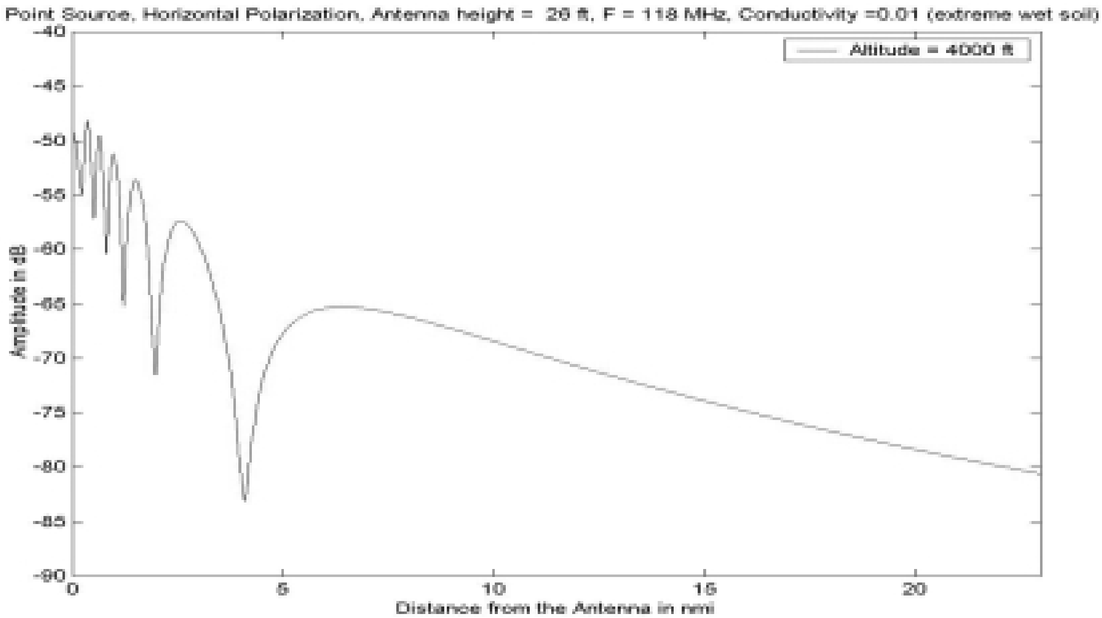

Point Source, Horizontal Polarization, Antenna height = 26 ft, F = 118 MHz, Perfect conductor
Altitude = 8000 ft
Amplitude in dB
Distance from the Antenna in nmi

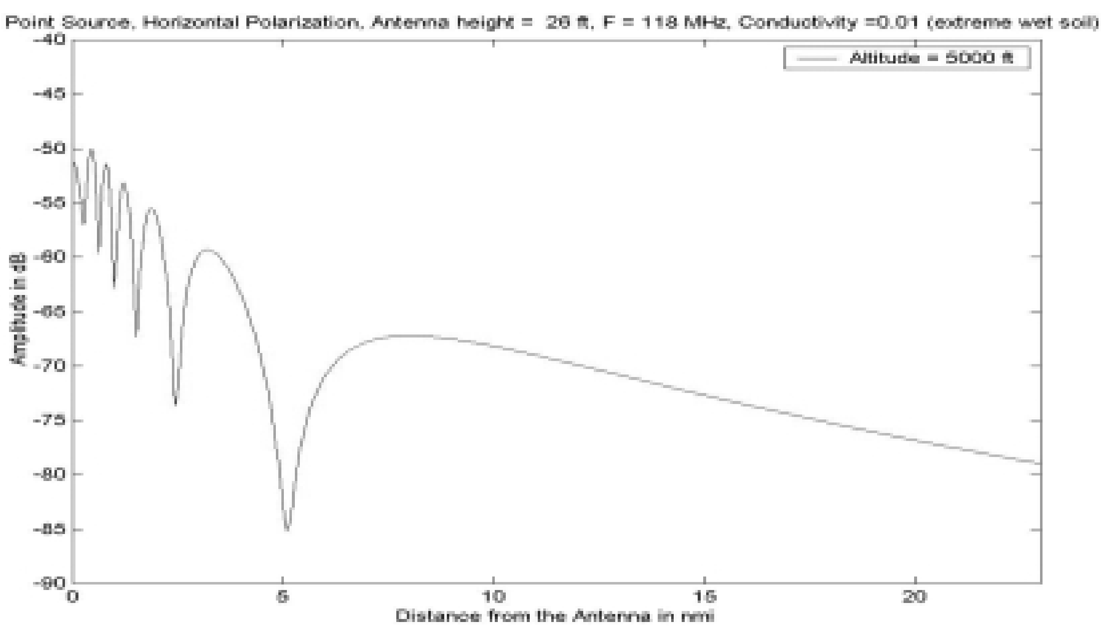

Point Source, Horizontal Polarization, Antenna height = 26 ft, F = 118 MHz, Perfect conductor
Altitude = 9000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

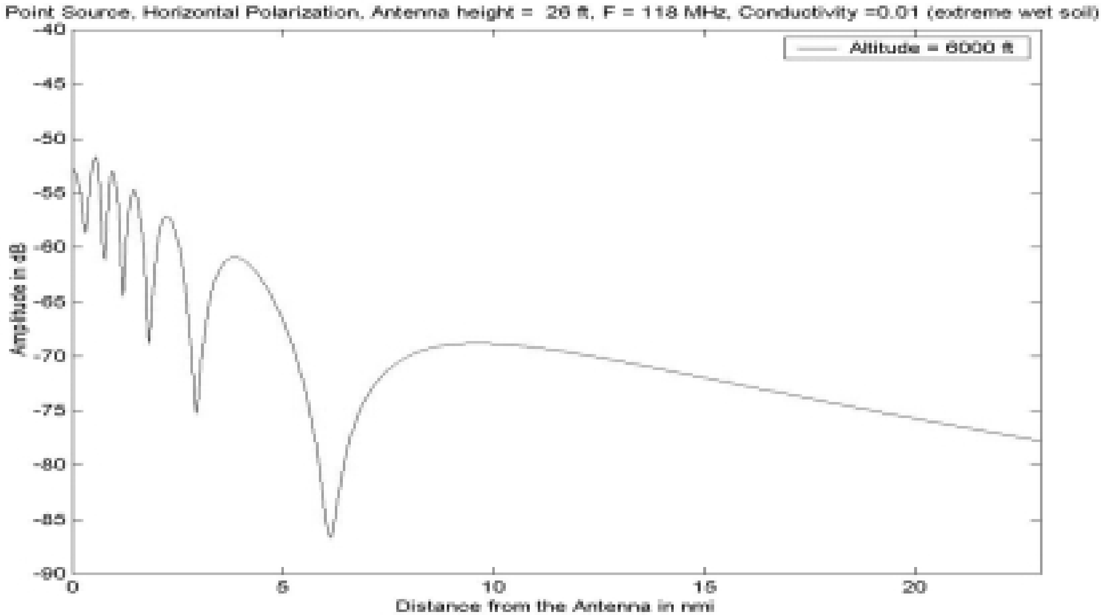

Point Source, Horizontal Polarization, Antenna height = 26 ft, F = 118 MHz, Perfect conductor
Altitude = 10,000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20


Point Source, Horizontal Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 2000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

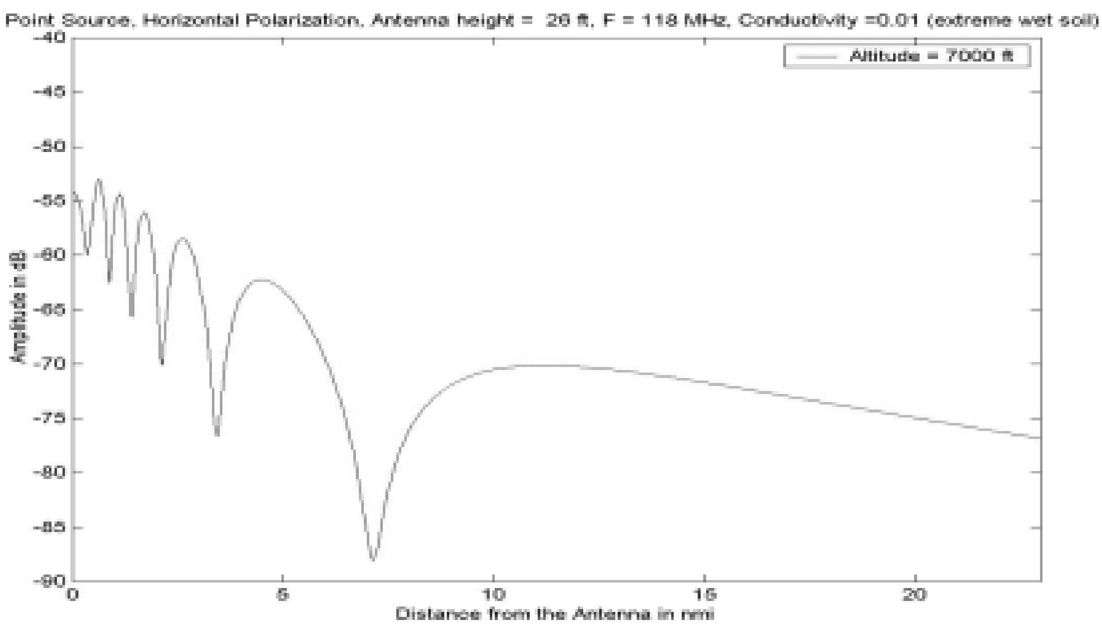

Point Source, Horizontal Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 3000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20


Point Source, Horizontal Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 4000 ft
Amplitude in dB
Distance from the Antenna in nmi

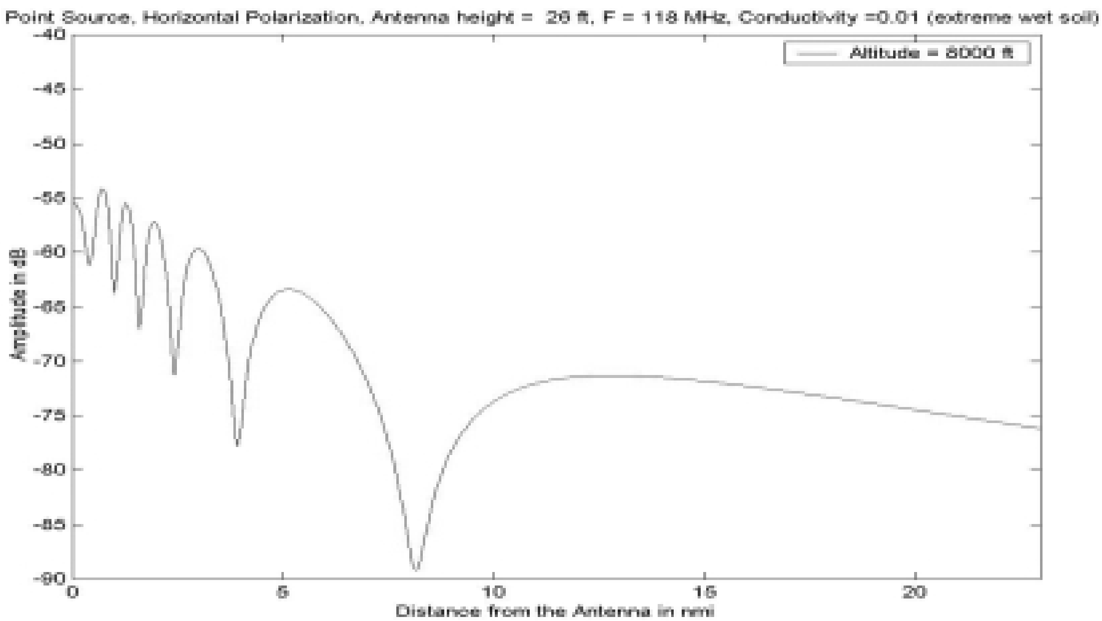

Point Source, Horizontal Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 5000 ft
Amplitude in dB
Distance from the Antenna in nmi

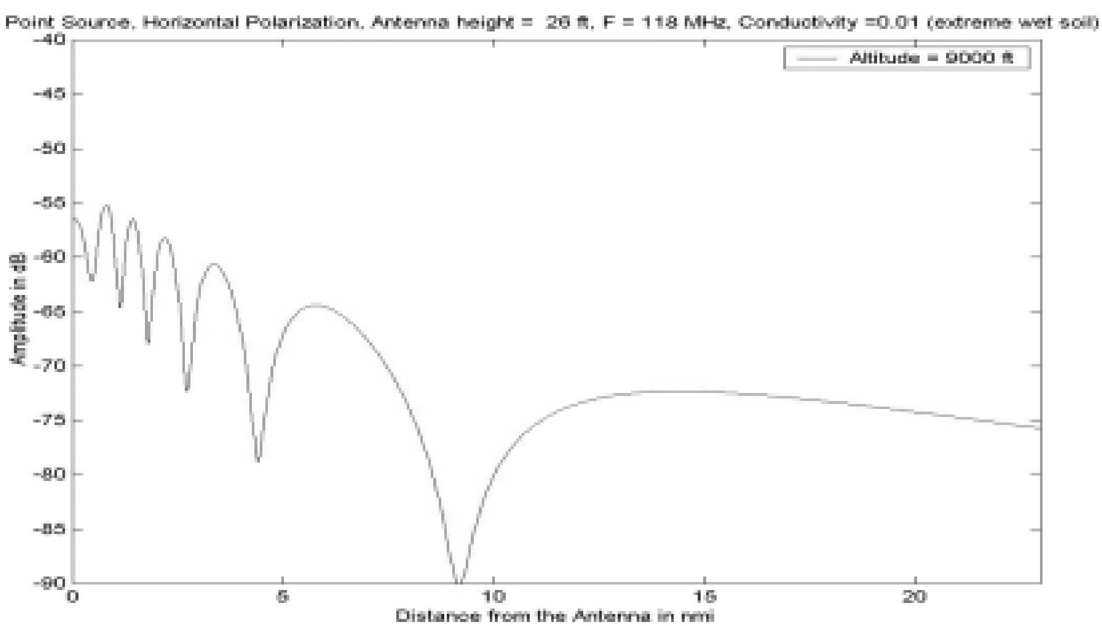


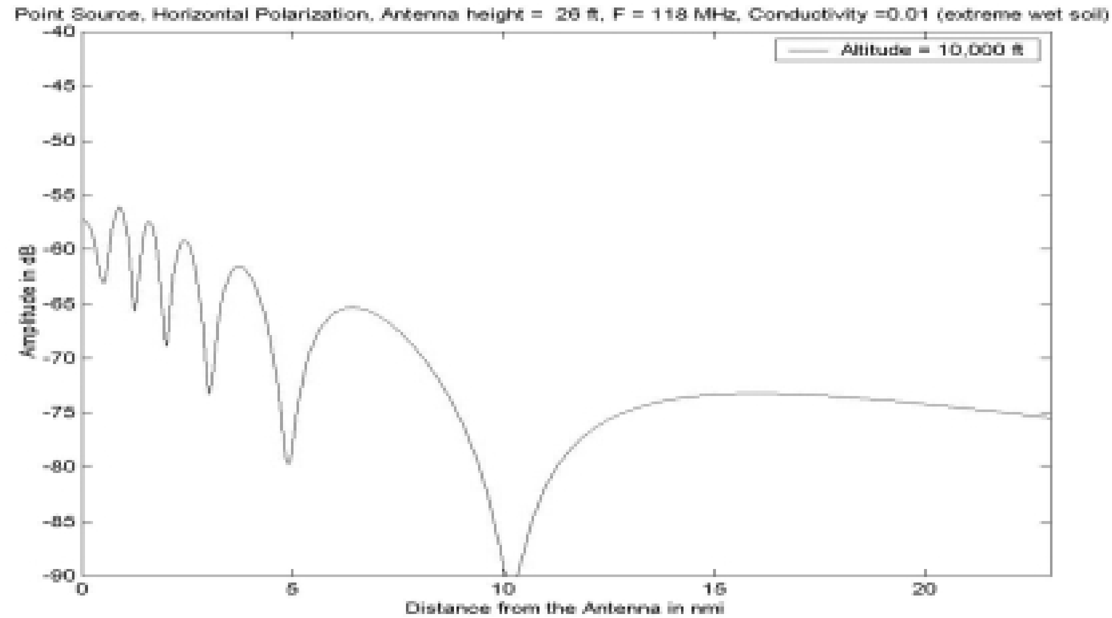
Point Source, Horizontal Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 6000 ft
Amplitude in dB
Distance from the Antenna in nmi

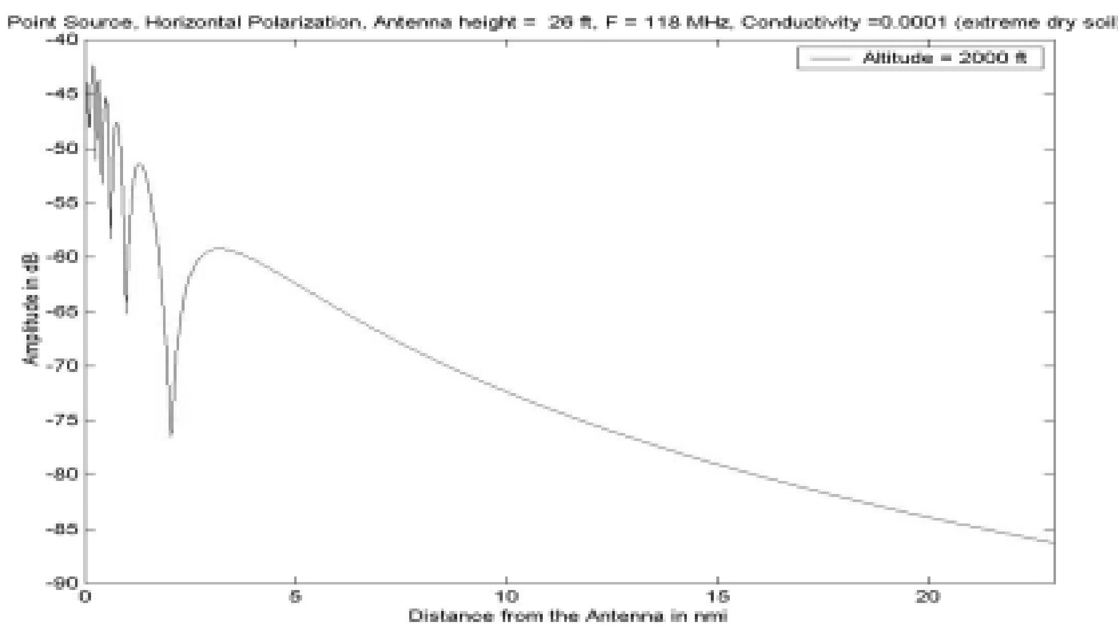


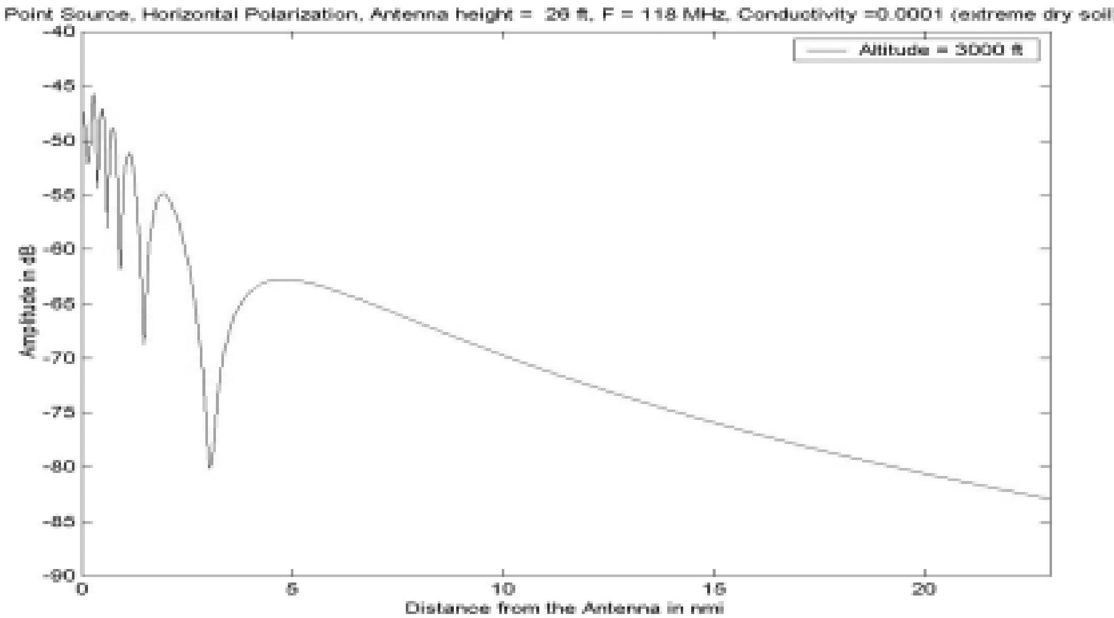
Point Source, Horizontal Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 7000 ft
Amplitude in dB
Distance from the Antenna in nmi

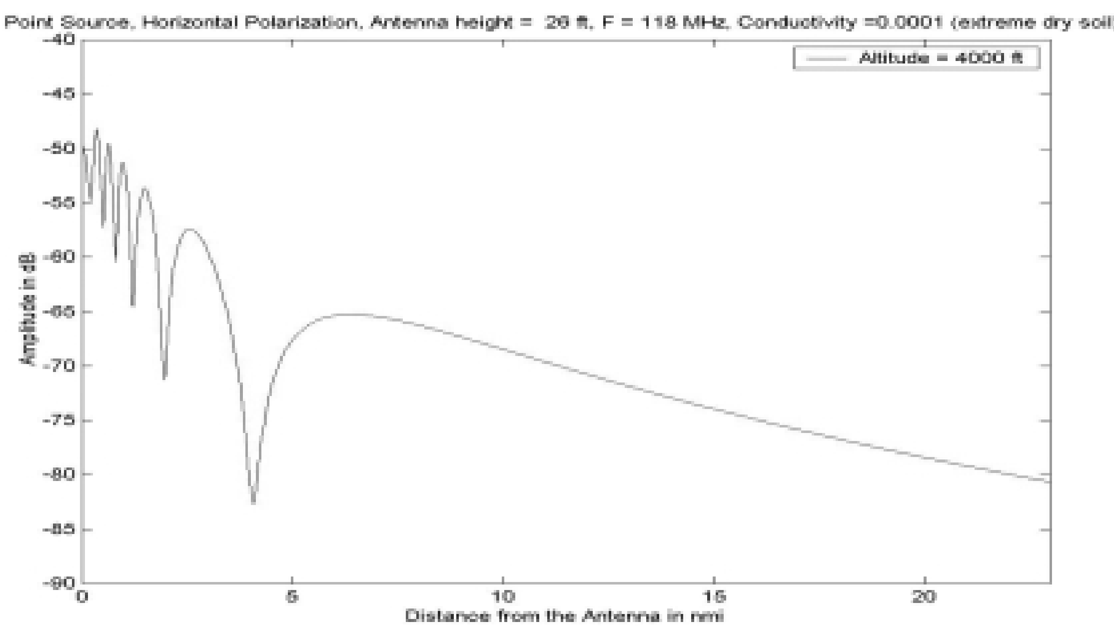

Point Source, Horizontal Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 8000 ft
Amplitude in dB
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20
Distance from the Antenna in nmi

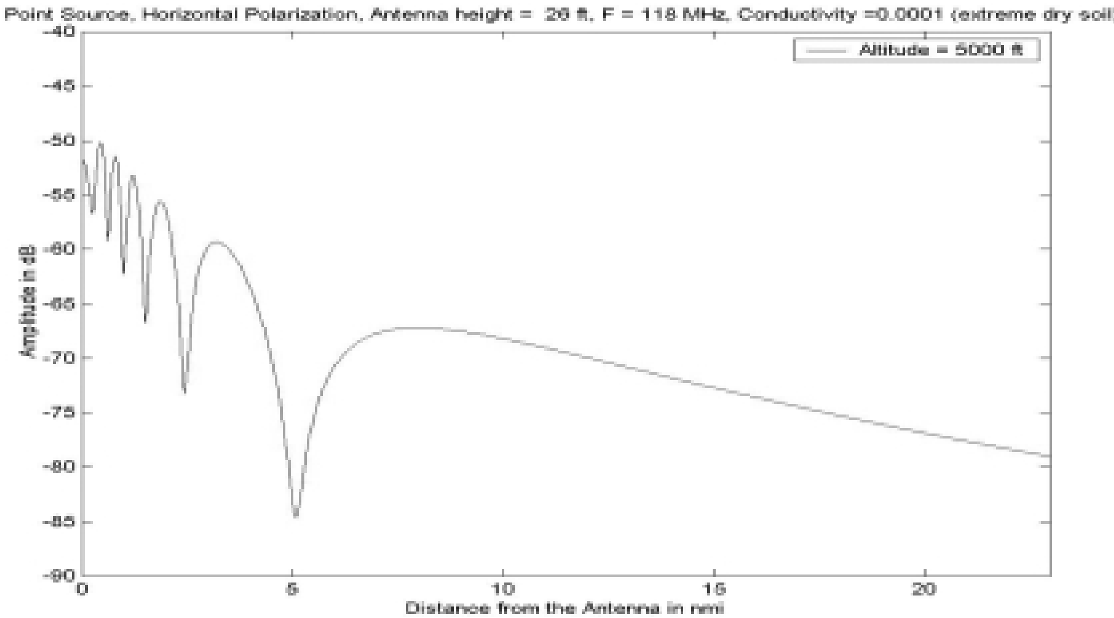

Point Source, Horizontal Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 9000 ft
Amplitude in dB
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20
Distance from the Antenna in nmi

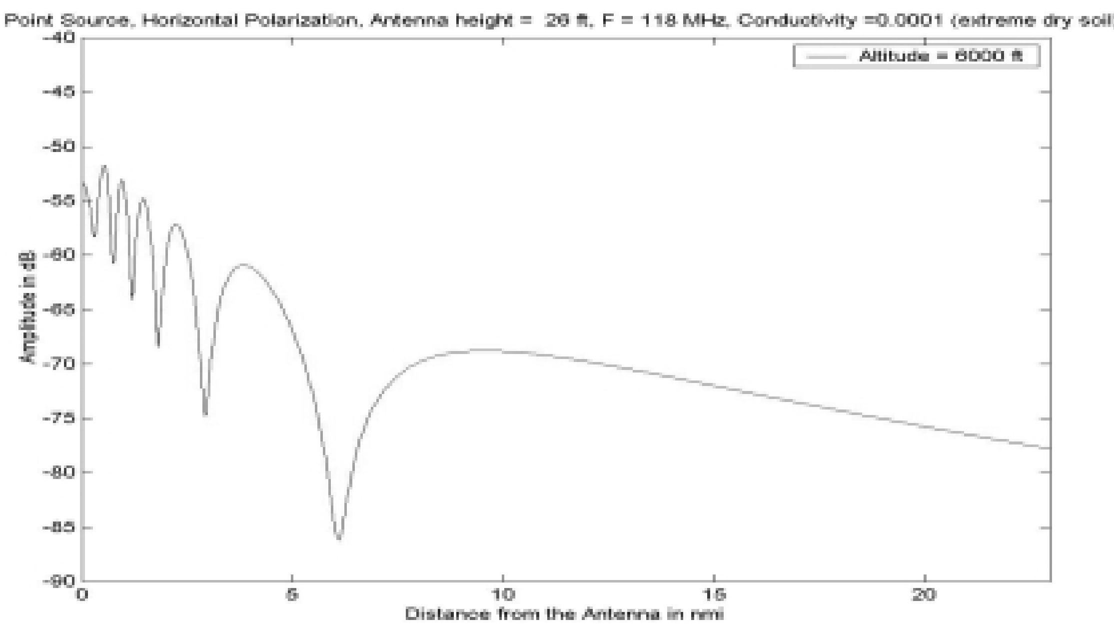

Point Source, Horizontal Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 10,000 ft
Amplitude in dB
Distance from the Antenna in nmi

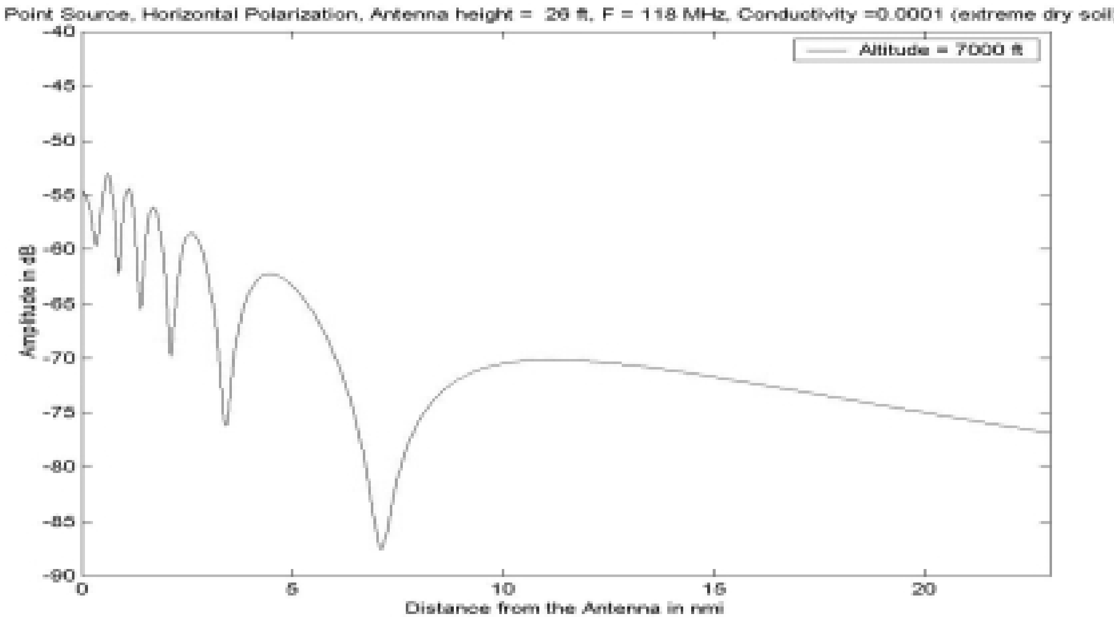

Point Source, Horizontal Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 2000 ft
Amplitude in dB
Distance from the Antenna in nmi

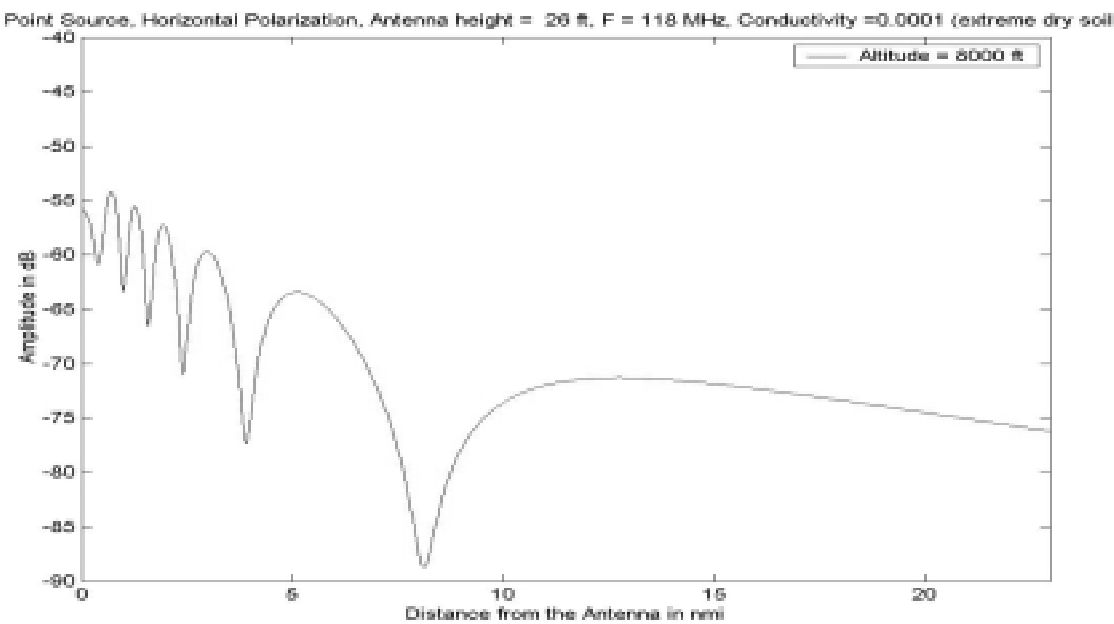

Point Source, Horizontal Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 3000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

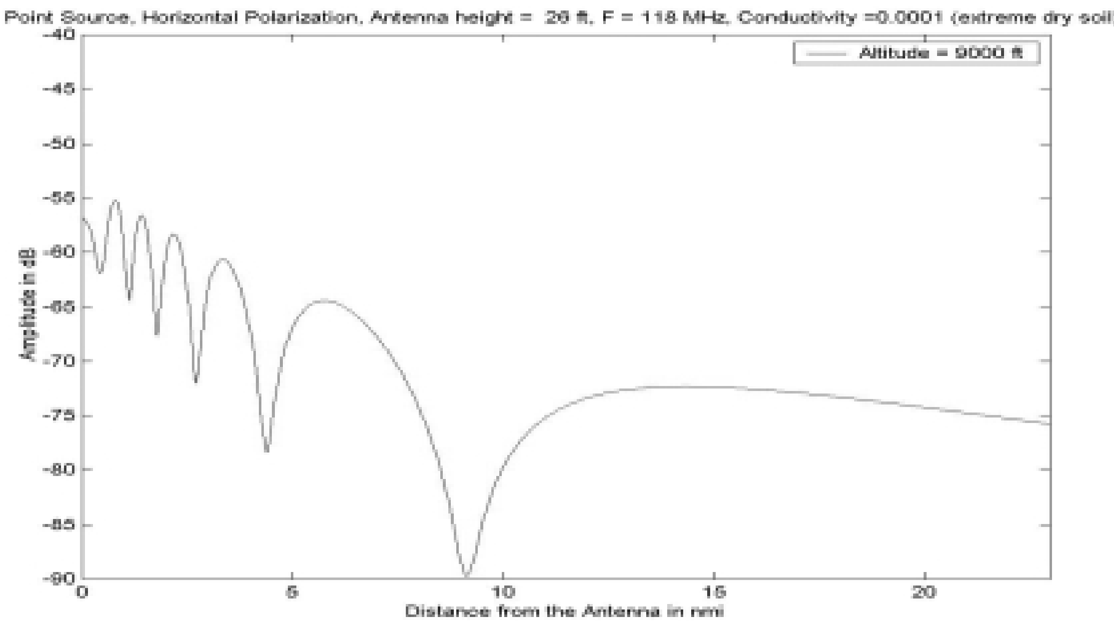

Point Source, Horizontal Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 4000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

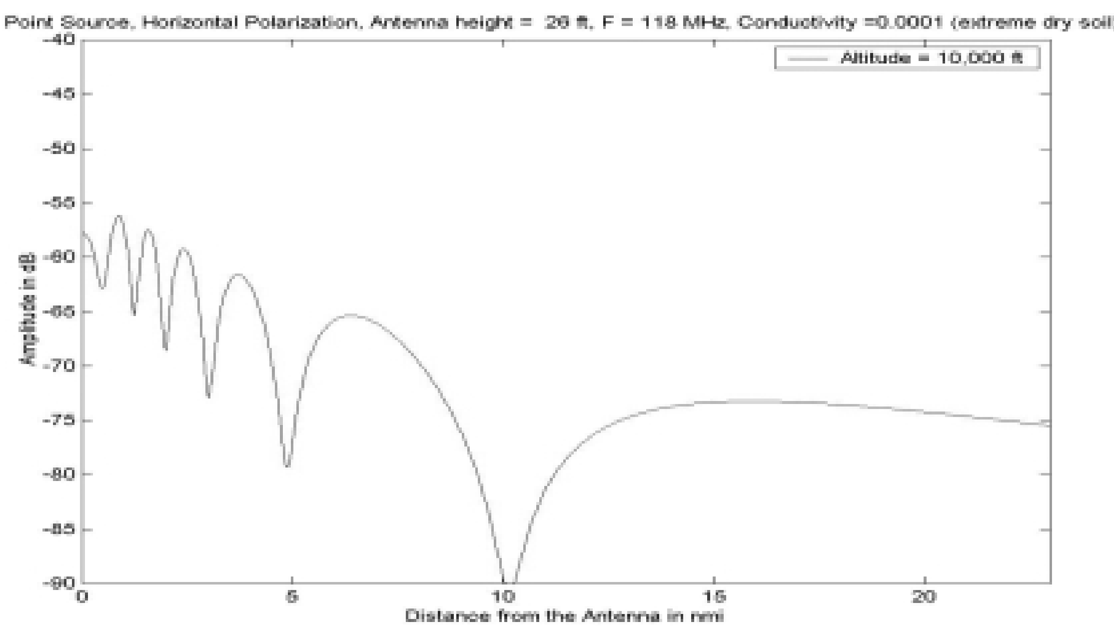

Point Source, Horizontal Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 5000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

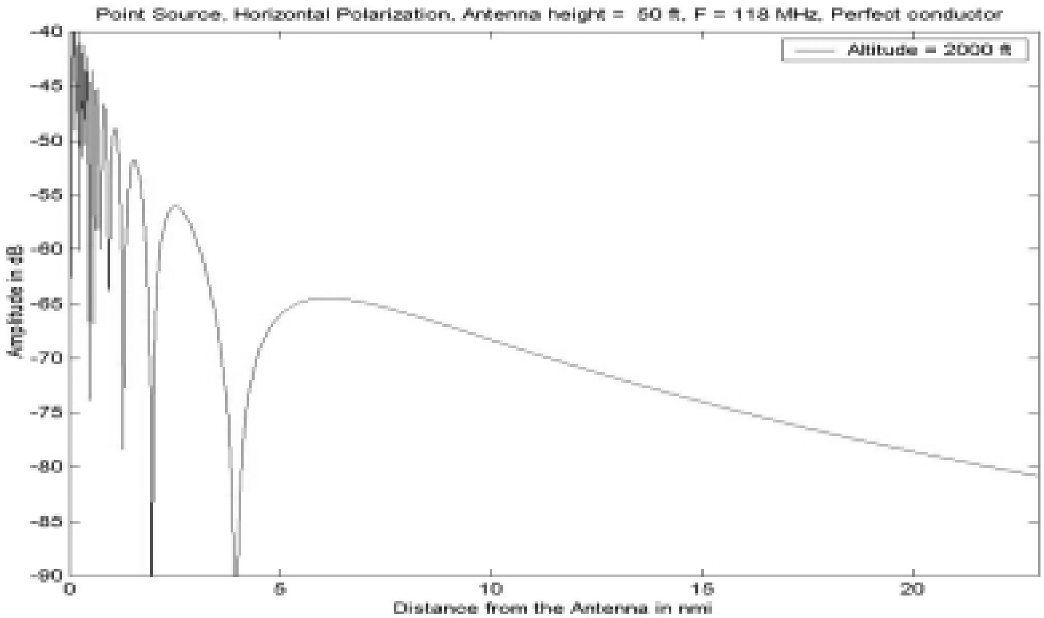

Point Source, Horizontal Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 6000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

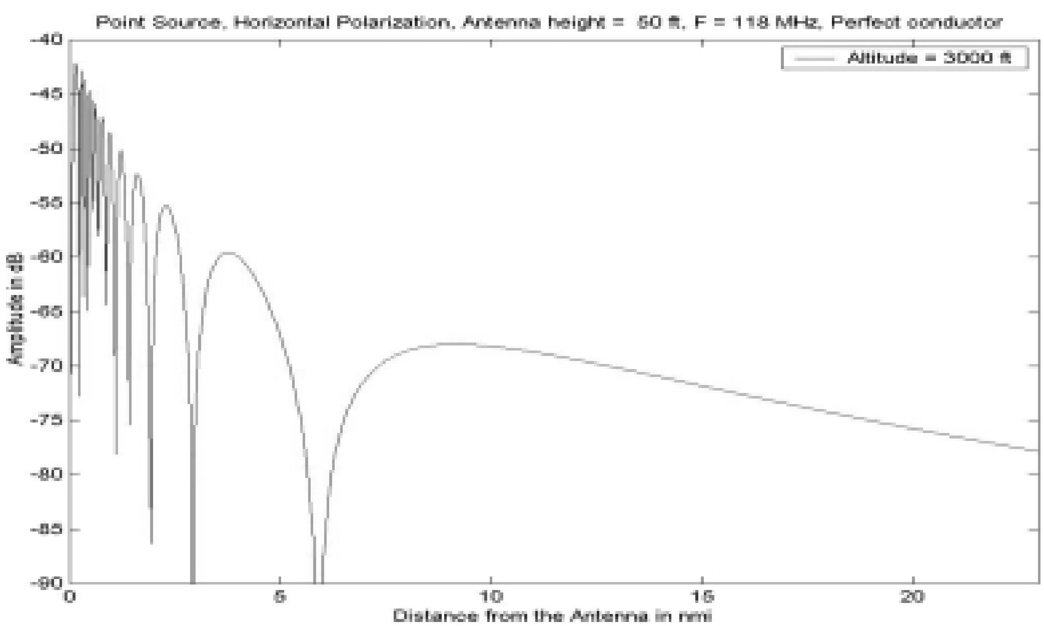

Point Source, Horizontal Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 7000 ft
Amplitude in dB
Distance from the Antenna in nmi

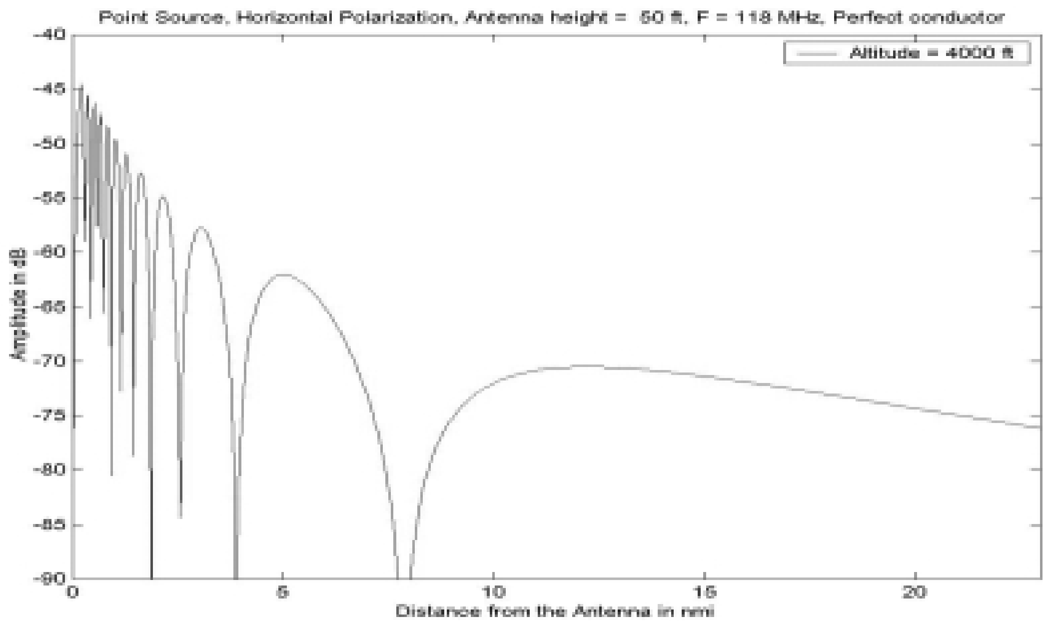

Point Source, Horizontal Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 8000 ft
Amplitude in dB
Distance from the Antenna in nmi

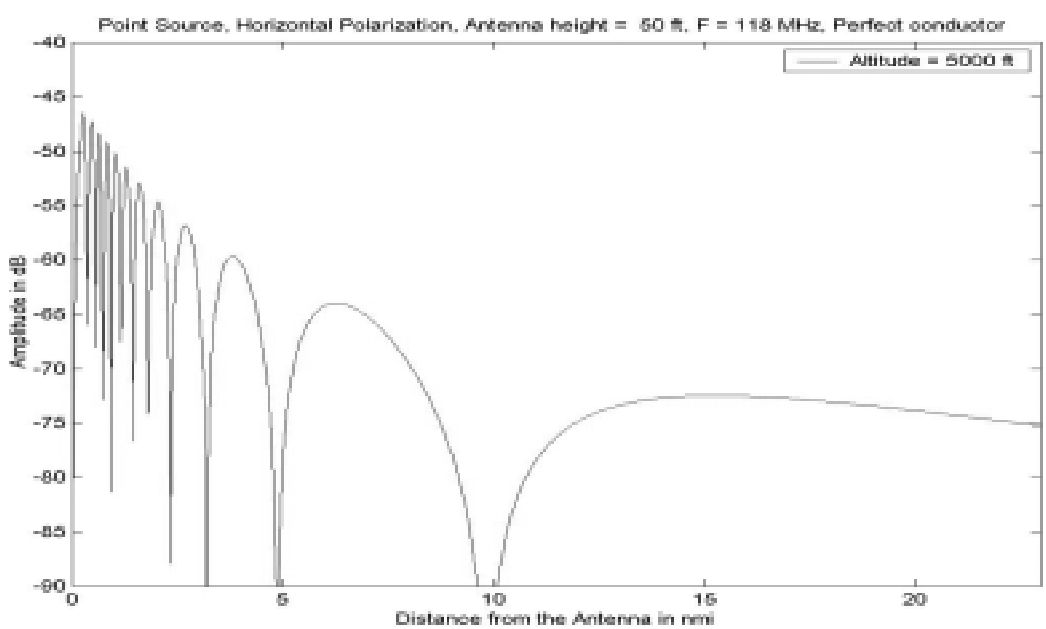

Point Source, Horizontal Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 9000 ft
Amplitude in dB
Distance from the Antenna in nmi

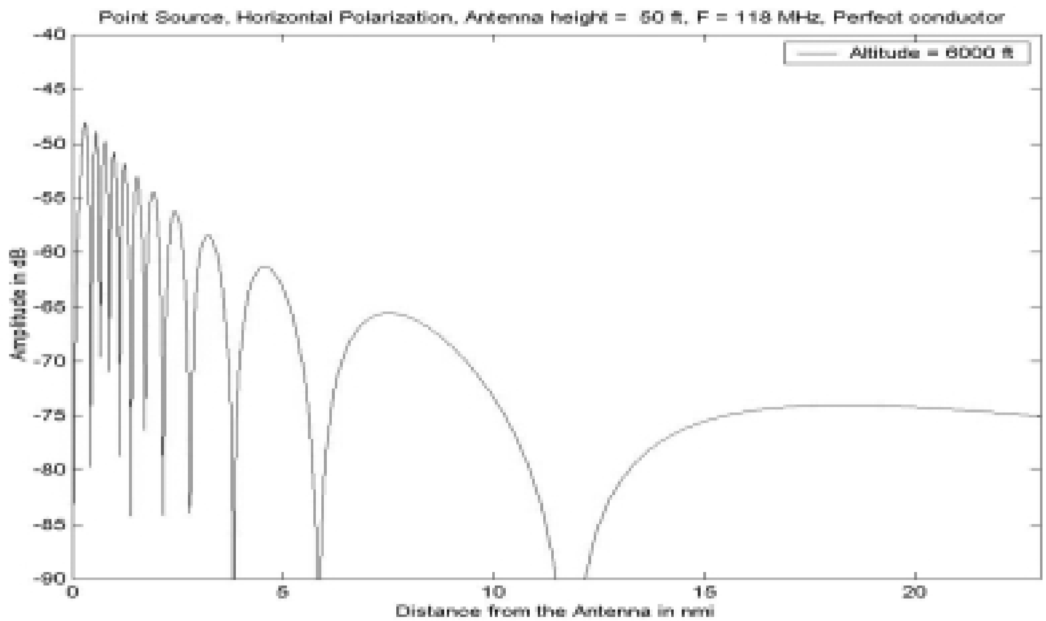

Point Source, Horizontal Polarization, Antenna height = 26 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 10,000 ft
Amplitude in dB
Distance from the Antenna in nmi

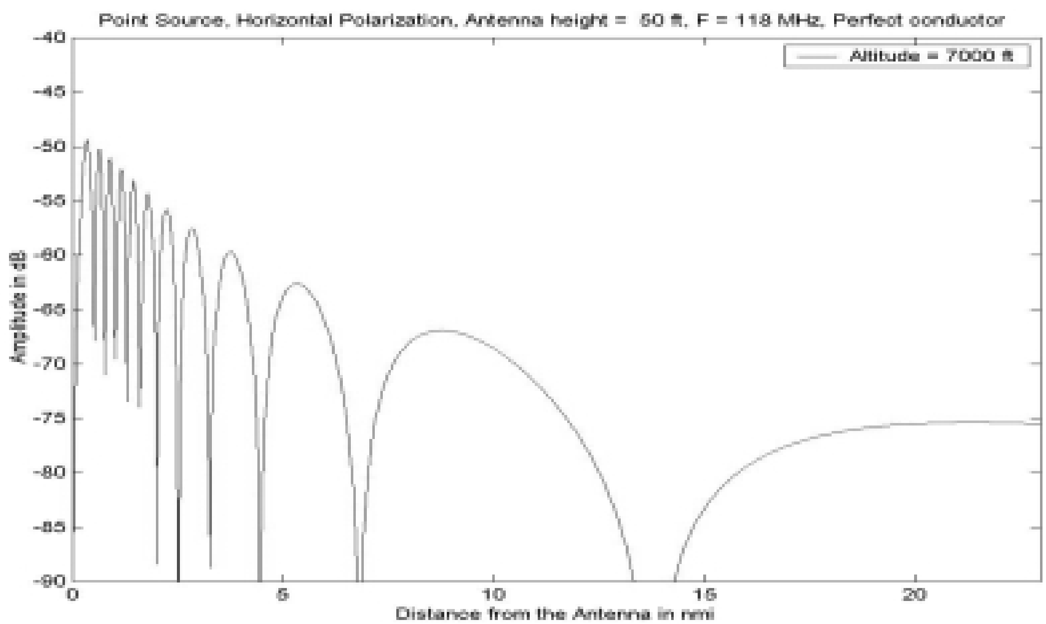

Point Source, Horizontal Polarization, Antenna height = 50 ft, F = 118 MHz, Perfect conductor
Altitude = 2000 ft
Amplitude in dB
Distance from the Antenna in nmi

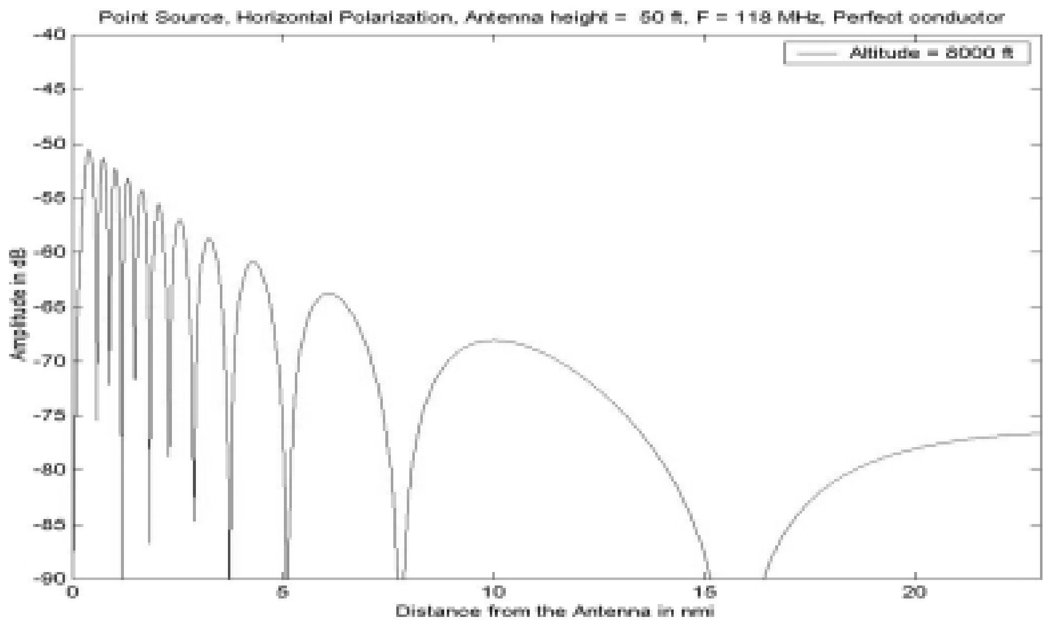

Point Source, Horizontal Polarization, Antenna height = 50 ft, F = 118 MHz, Perfect conductor
Altitude = 3000 ft
Amplitude in dB
Distance from the Antenna in nmi

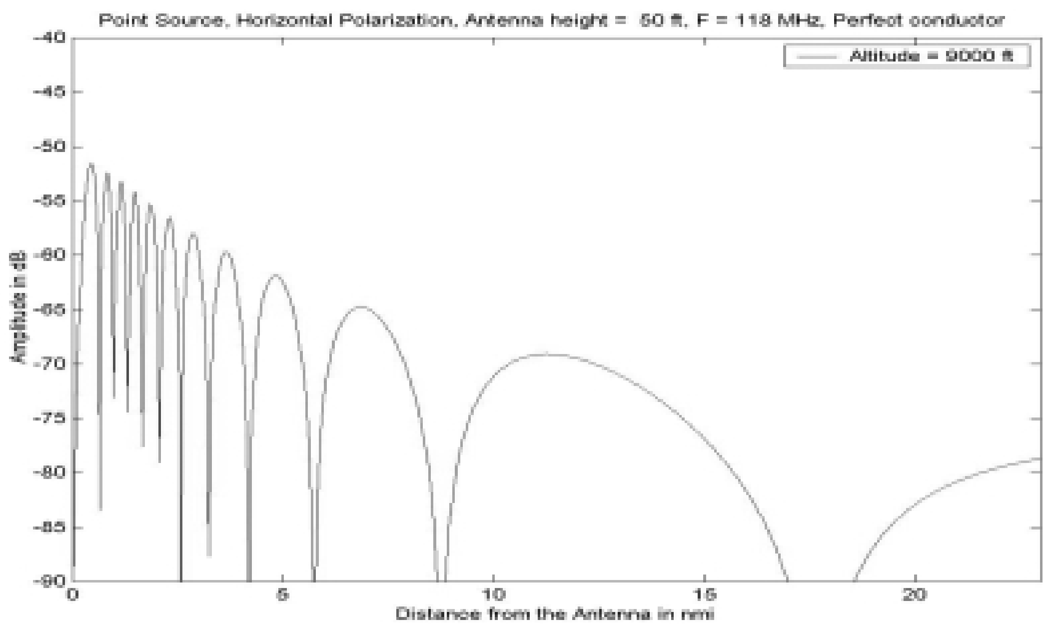

Point Source, Horizontal Polarization, Antenna height = 50 ft, F = 118 MHz, Perfect conductor
Altitude = 4000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

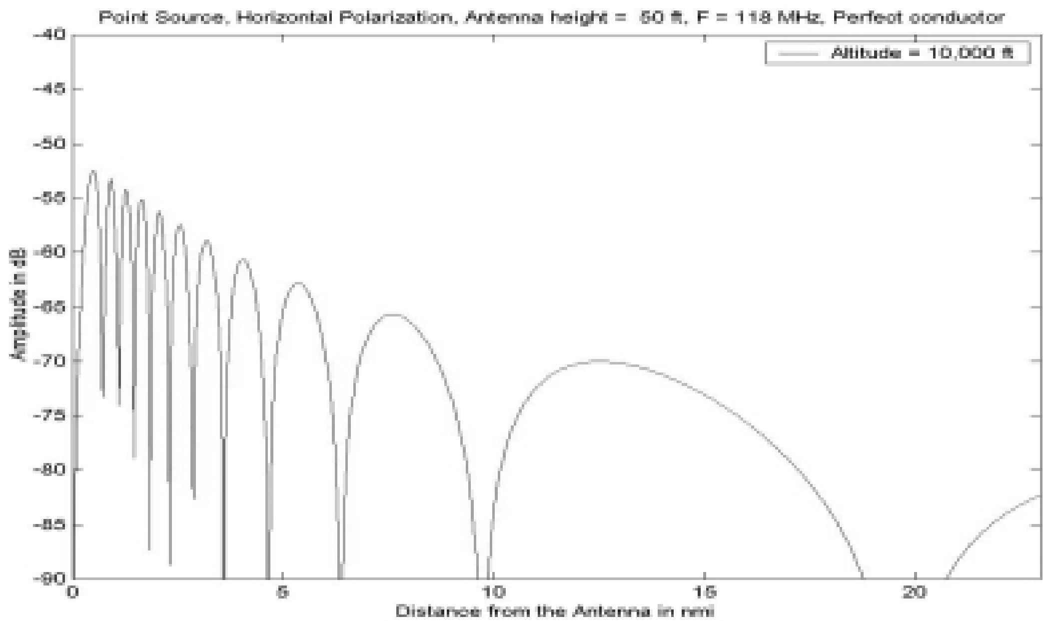

Point Source, Horizontal Polarization, Antenna height = 50 ft, F = 118 MHz, Perfect conductor
Altitude = 5000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

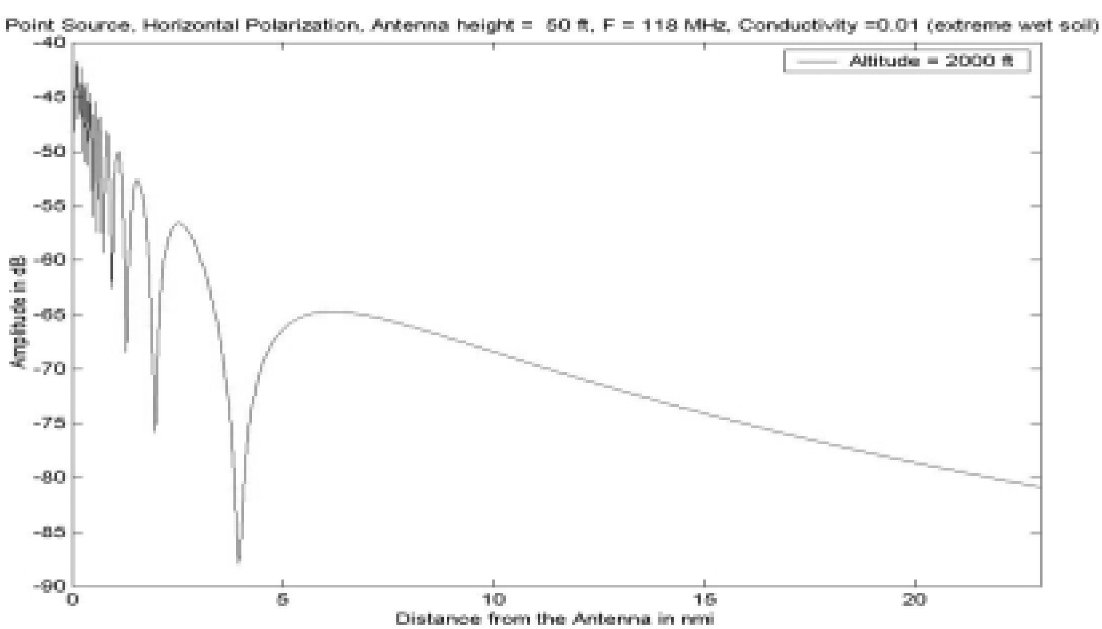

Point Source, Horizontal Polarization, Antenna height = 50 ft, F = 118 MHz, Perfect conductor
Altitude = 6000 ft
Amplitude in dB
Distance from the Antenna in nmi

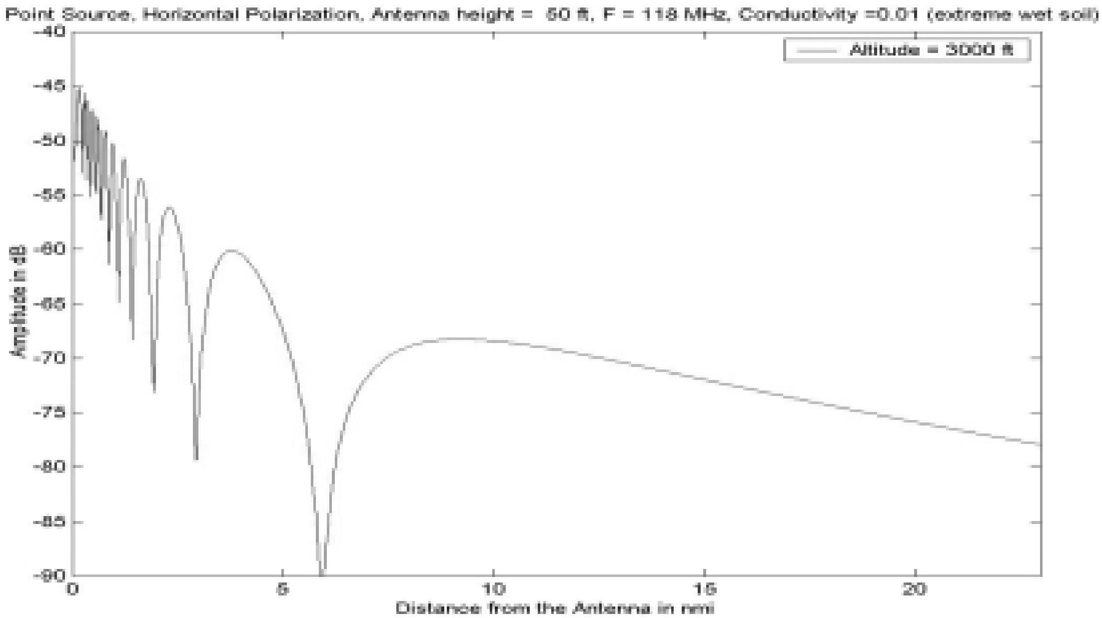

Point Source, Horizontal Polarization, Antenna height = 50 ft, F = 118 MHz, Perfect conductor
Altitude = 7000 ft
Amplitude in dB
Distance from the Antenna in nmi

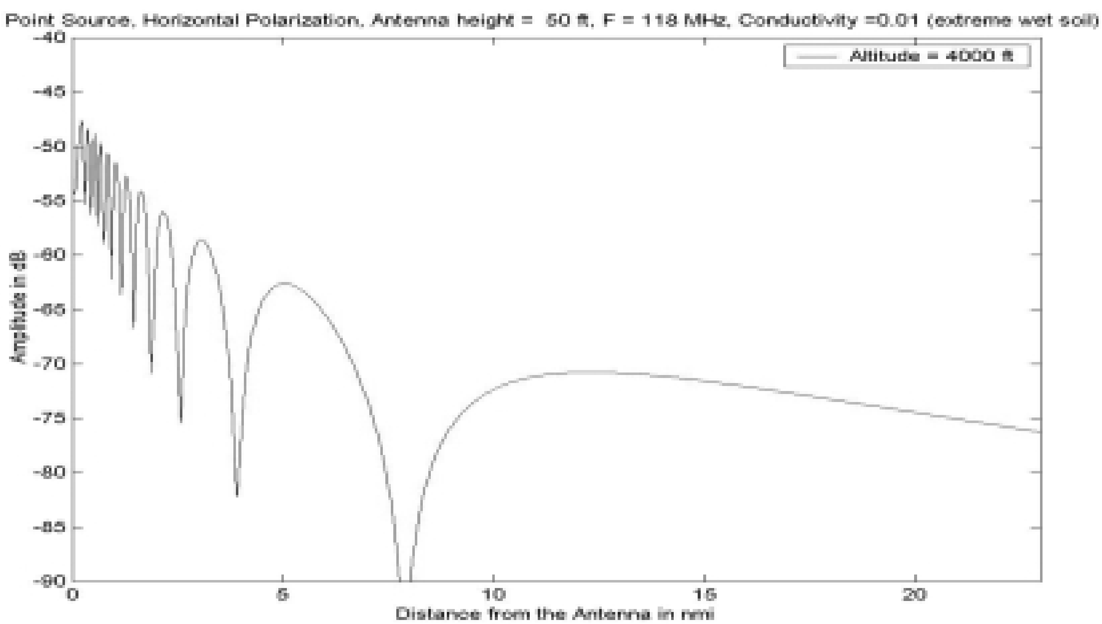

Point Source, Horizontal Polarization, Antenna height = 50 ft, F = 118 MHz, Perfect conductor
Altitude = 8000 ft
Amplitude in dB
Distance from the Antenna in nmi

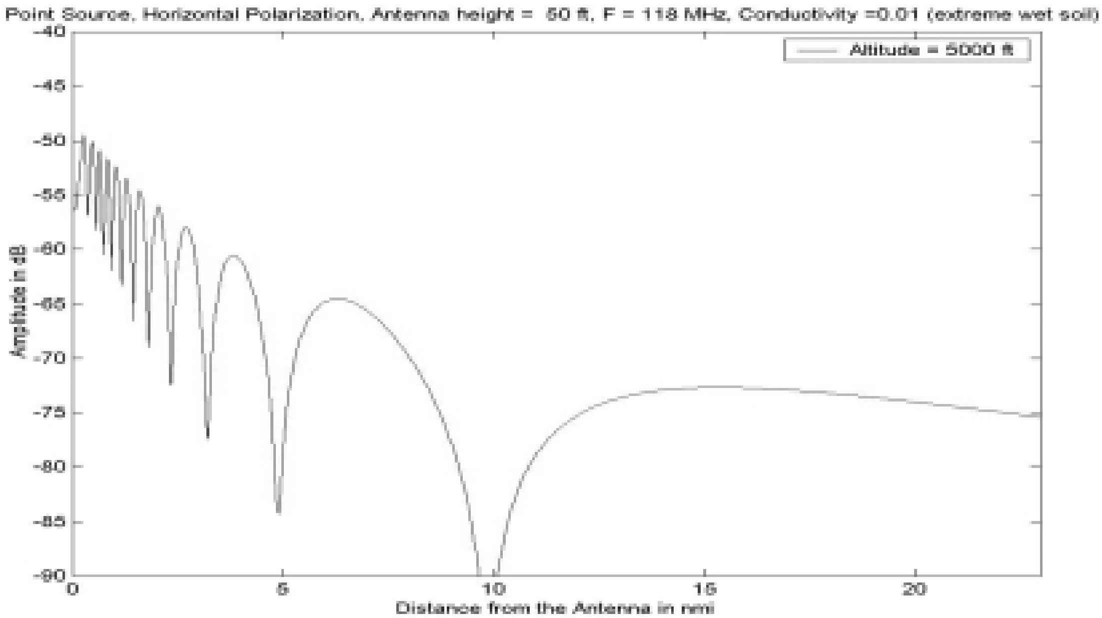

Point Source, Horizontal Polarization, Antenna height = 50 ft, F = 118 MHz, Perfect conductor
Altitude = 9000 ft
Amplitude in dB
Distance from the Antenna in nmi

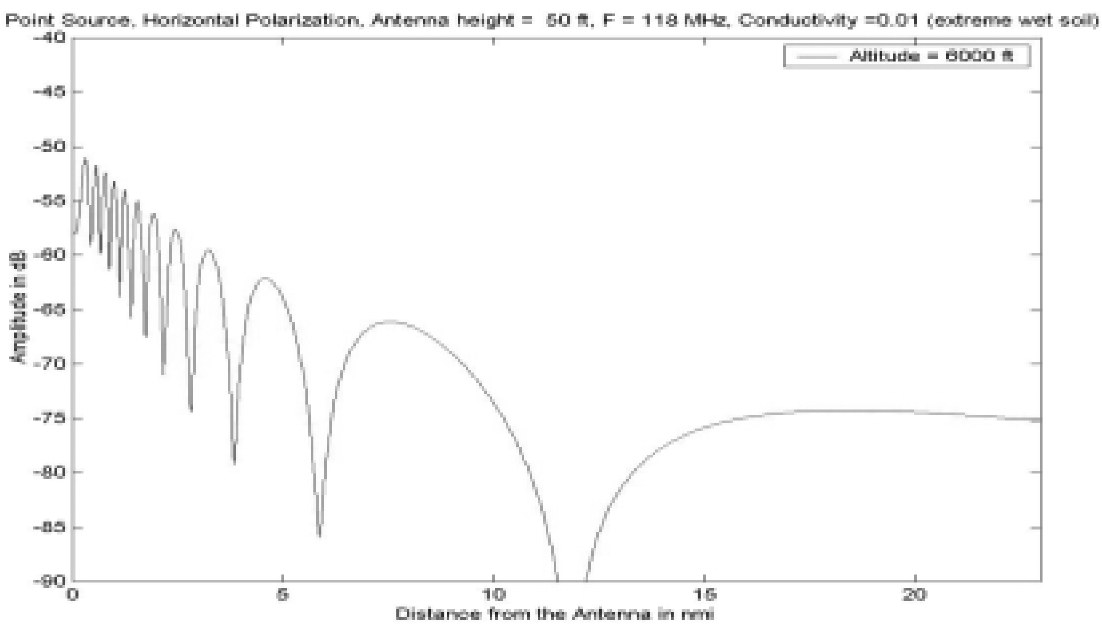

Point Source, Horizontal Polarization, Antenna height = 50 ft, F = 118 MHz, Perfect conductor
Altitude = 10,000 ft
Amplitude in dB
Distance from the Antenna in nmi

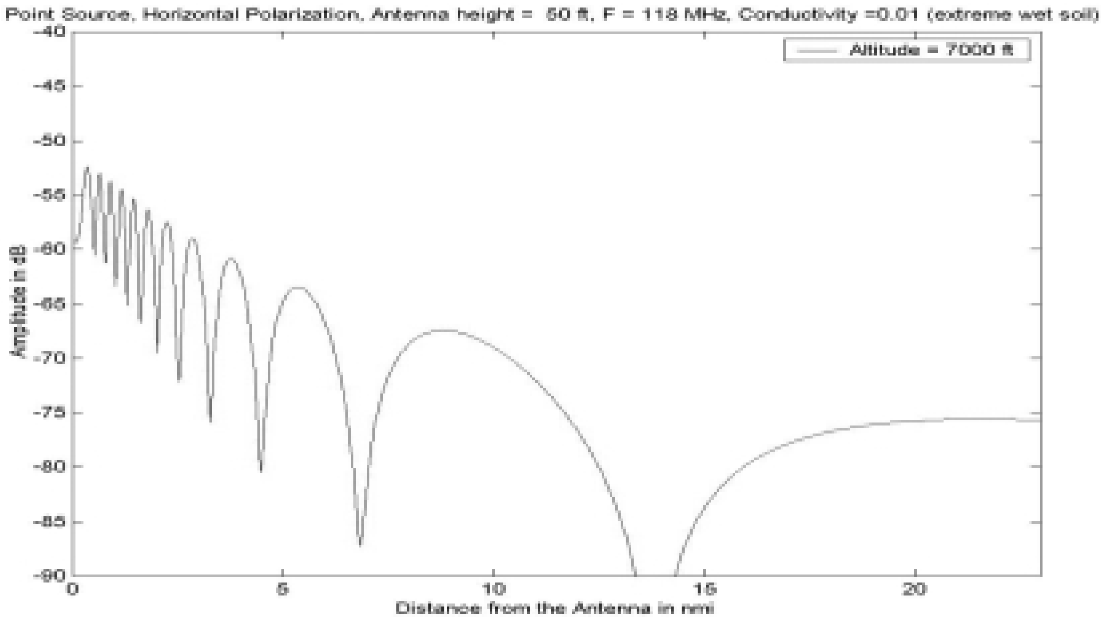

Point Source, Horizontal Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 2000 ft
Amplitude in dB
Distance from the Antenna in nmi

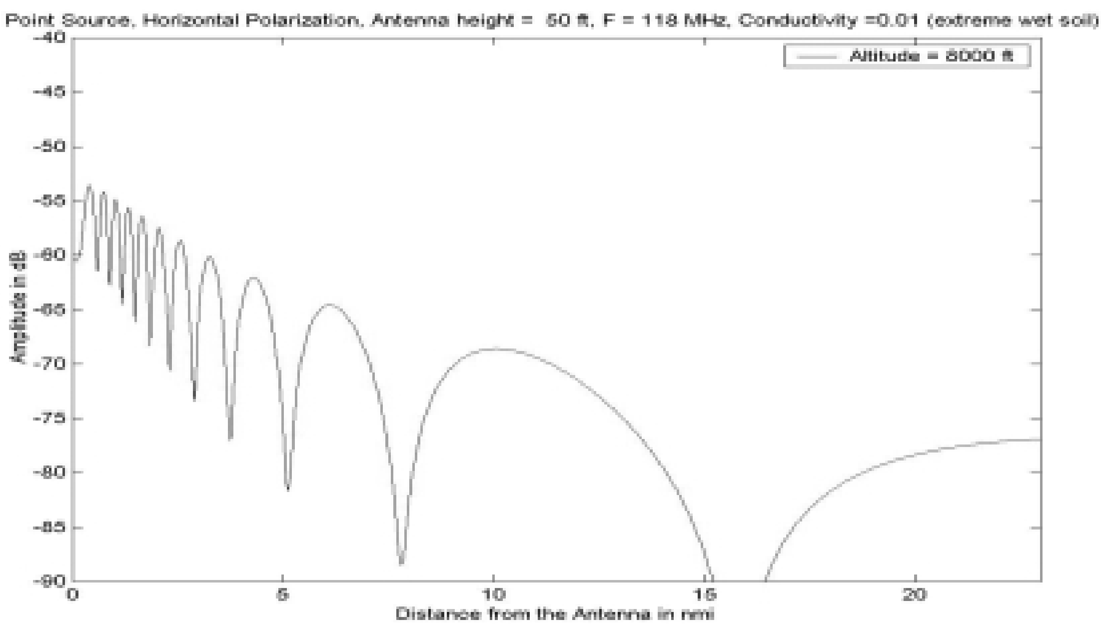

Point Source, Horizontal Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 3000 ft
Amplitude in dB
Distance from the Antenna in nmi

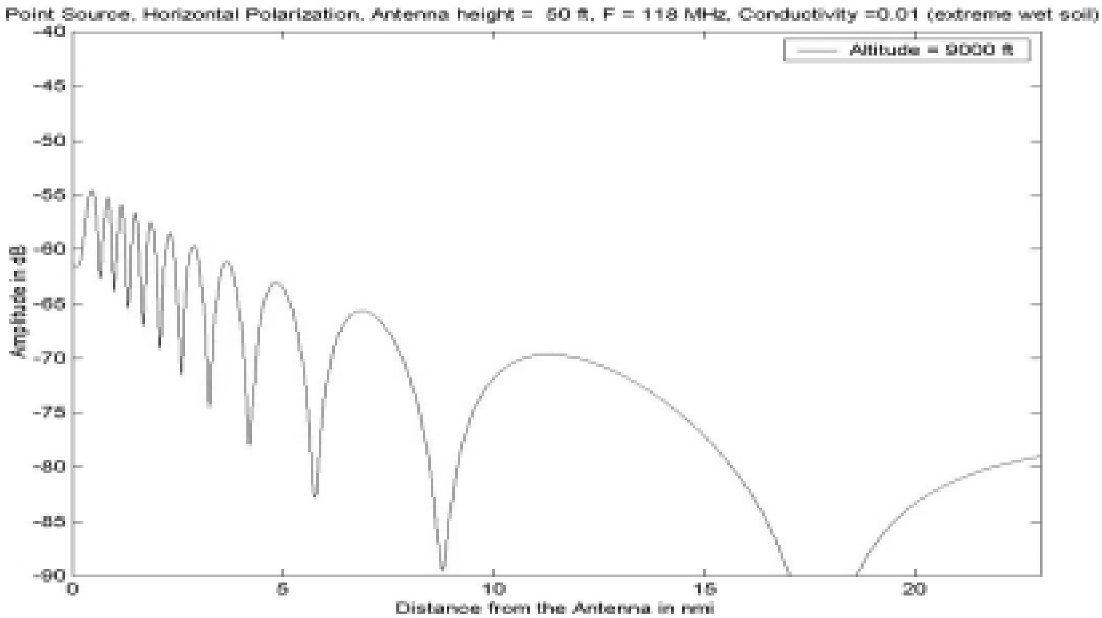

Point Source, Horizontal Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 4000 ft
Amplitude in dB
Distance from the Antenna in nmi

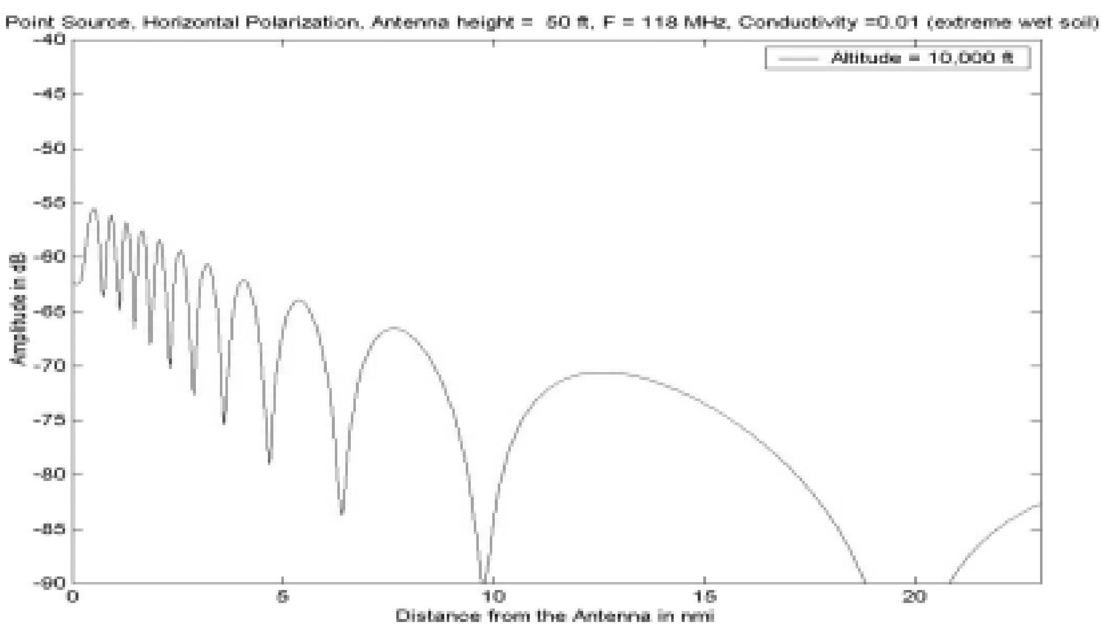

Point Source, Horizontal Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 5000 ft
Amplitude in dB
Distance from the Antenna in nmi

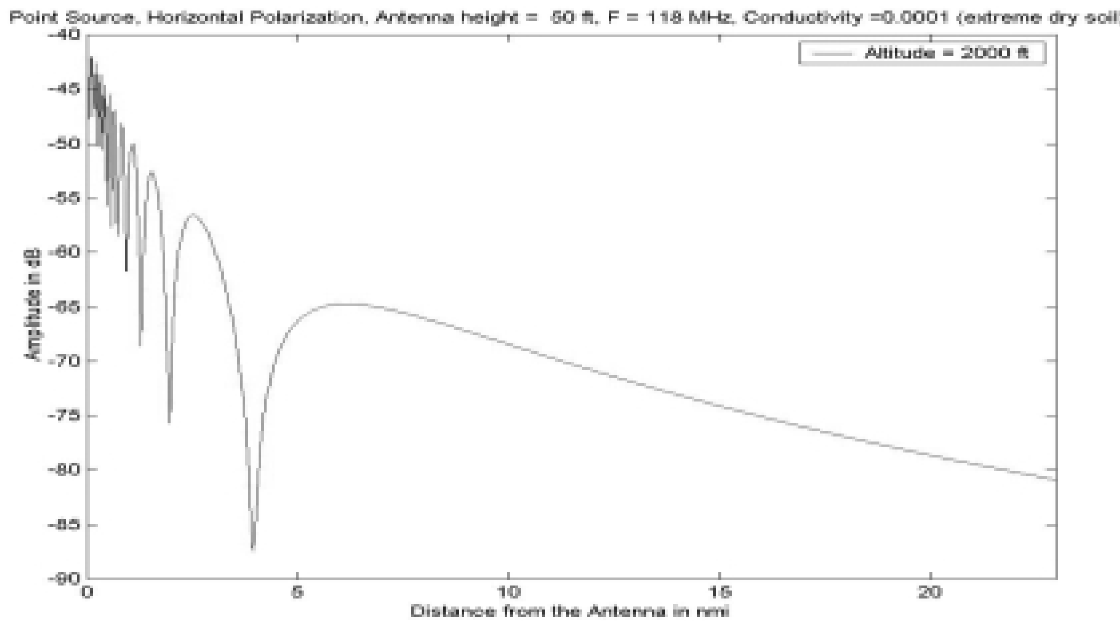

Point Source, Horizontal Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 6000 ft
Amplitude in dB
Distance from the Antenna in nmi


Point Source, Horizontal Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 7000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

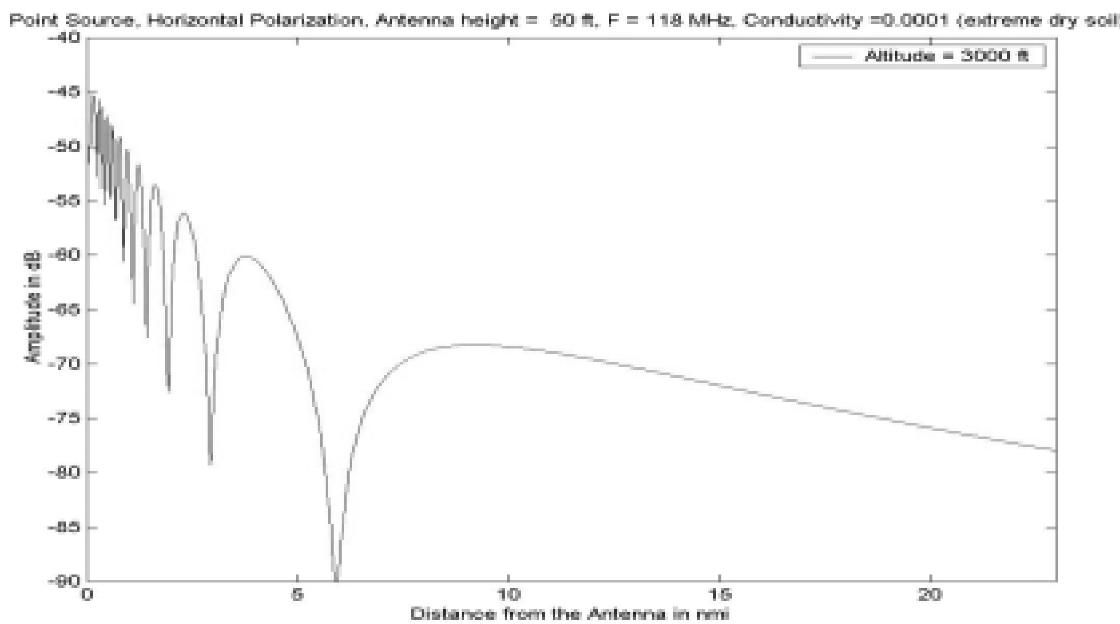

Point Source, Horizontal Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 8000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20


Point Source, Horizontal Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 9000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

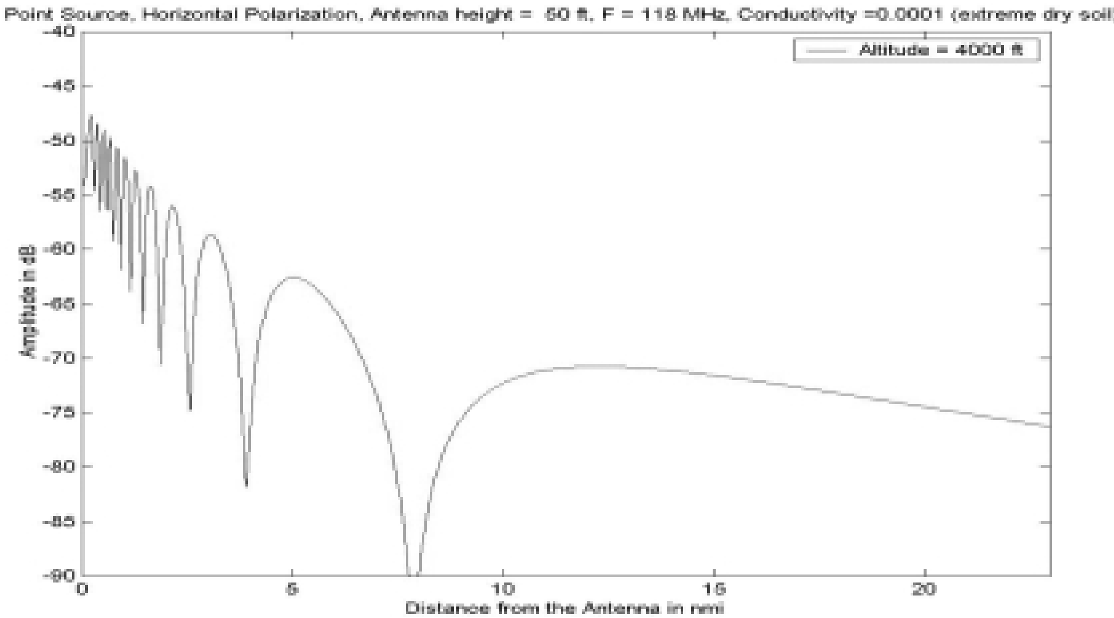

Point Source, Horizontal Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 10,000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

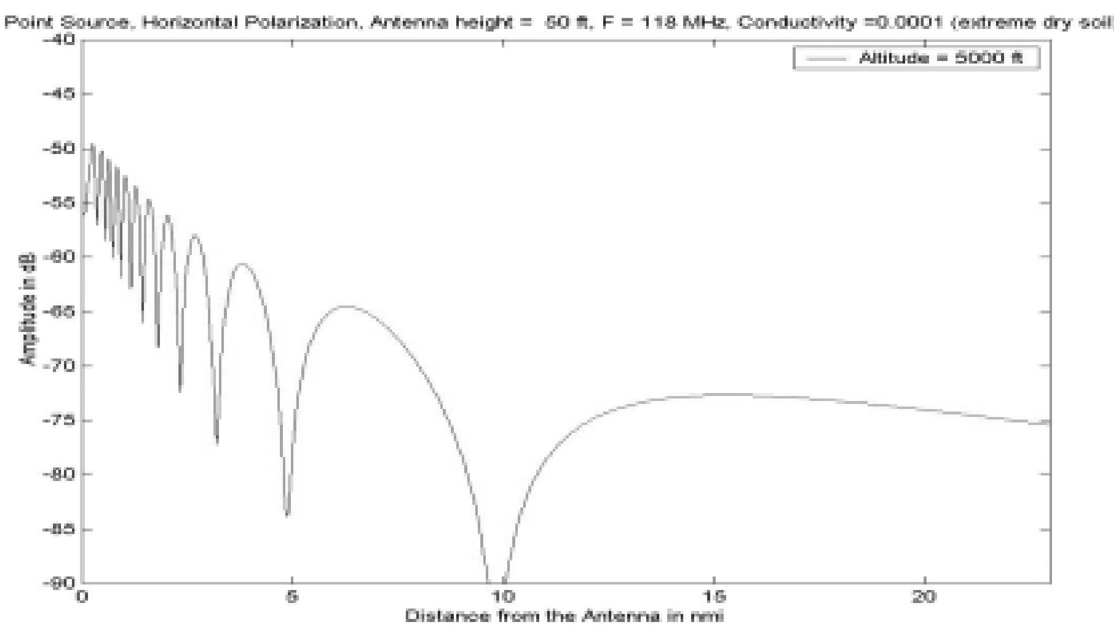


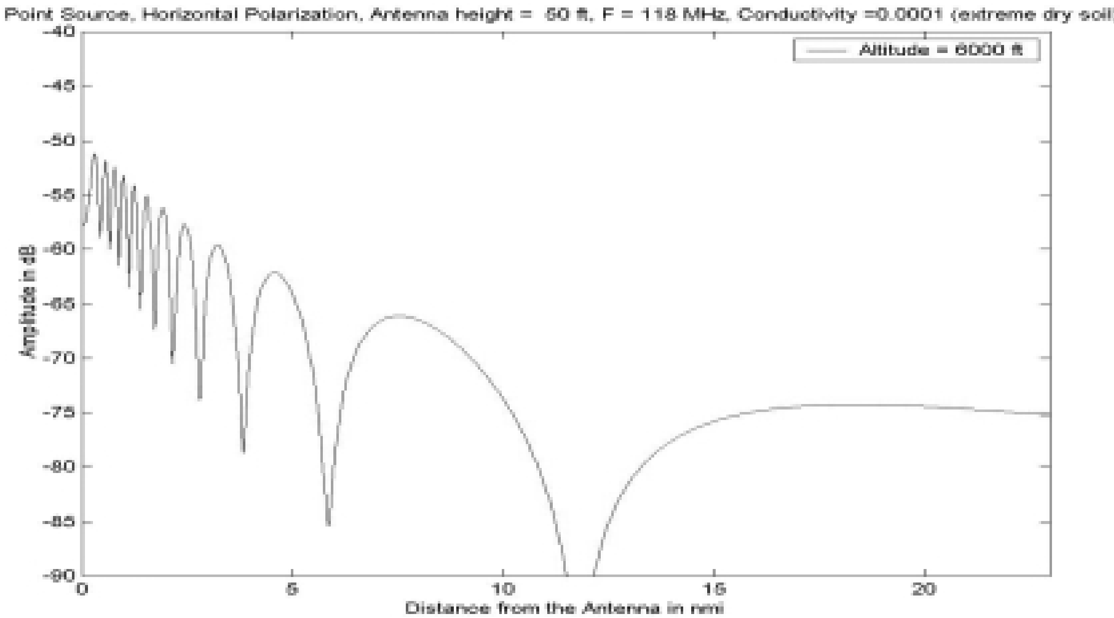
Point Source, Horizontal Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 2000 ft
Amplitude in dB
Distance from the Antenna in nmi

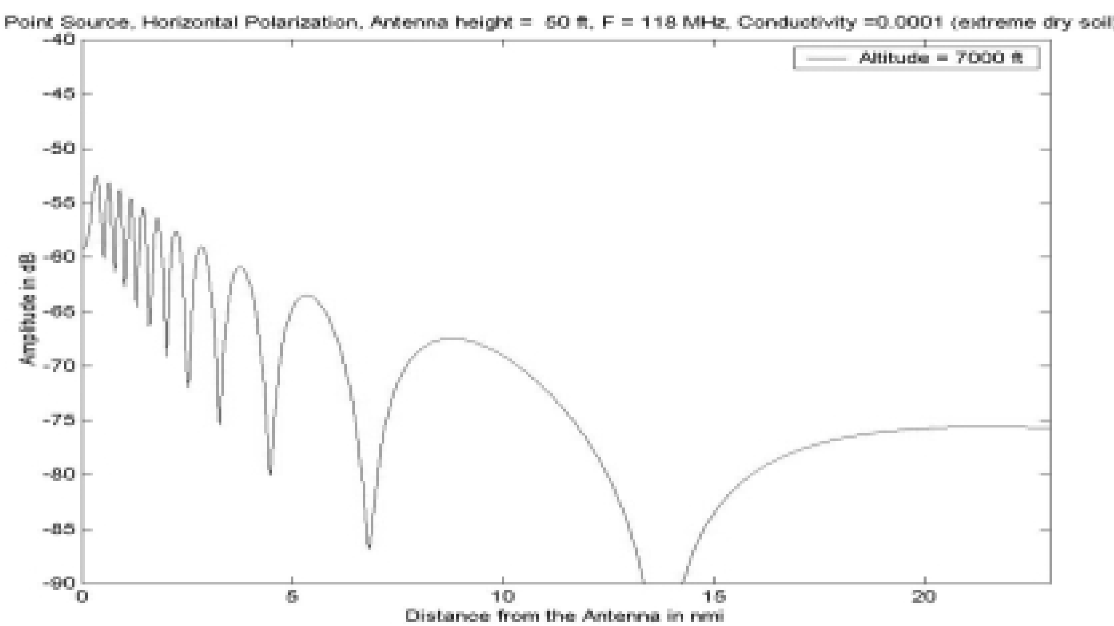


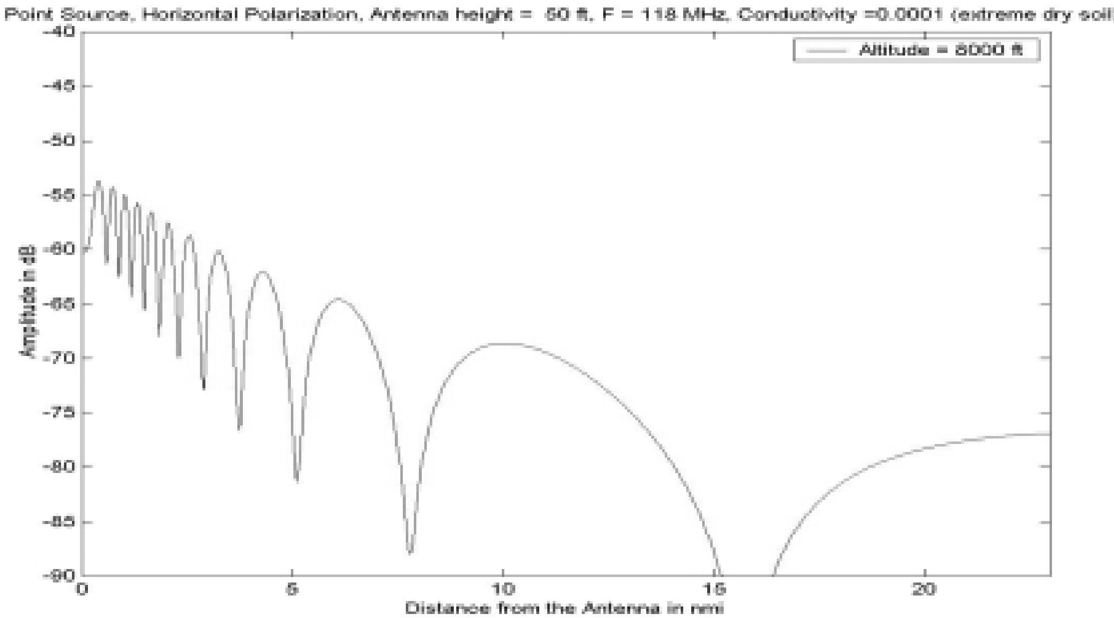
Point Source, Horizontal Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 3000 ft
Amplitude in dB
Distance from the Antenna in nmi

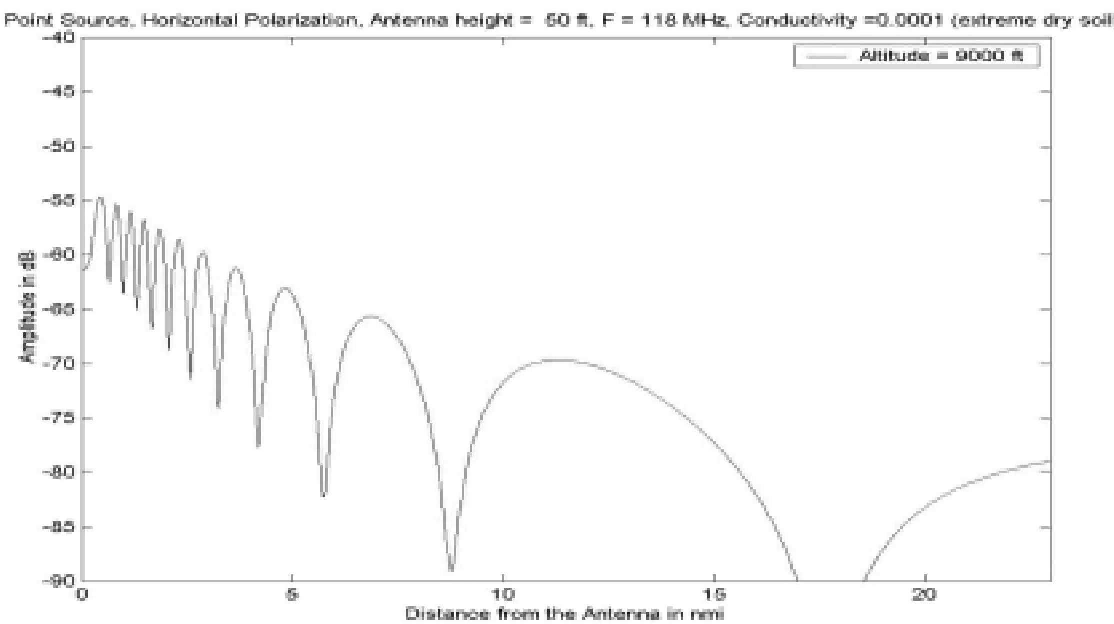

Point Source, Horizontal Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 4000 ft
Amplitude in dB
Distance from the Antenna in nmi

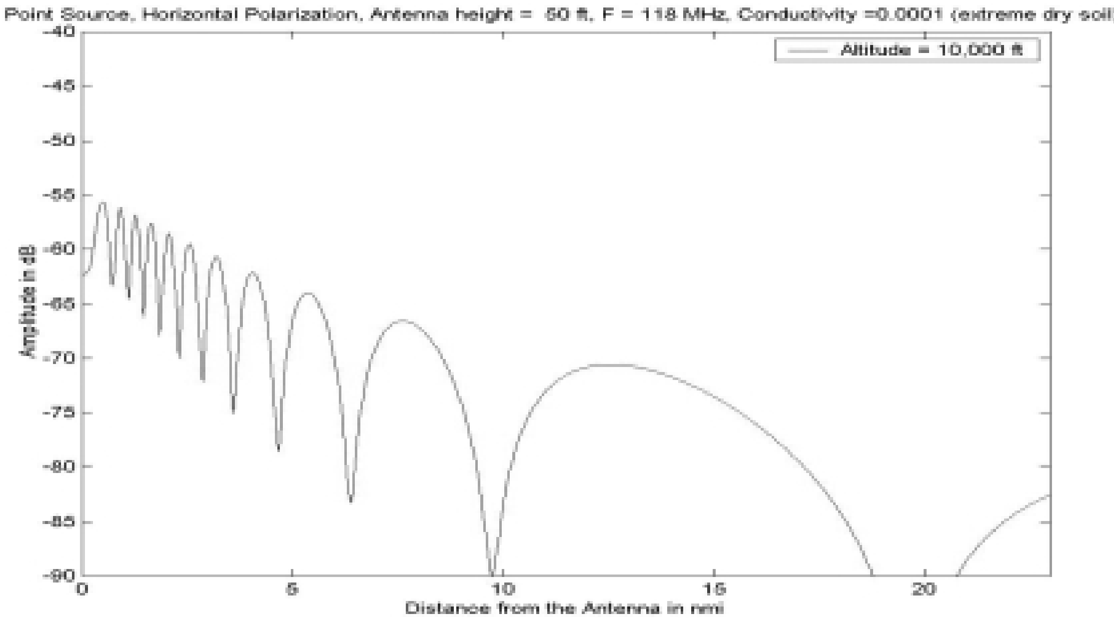

Point Source, Horizontal Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 5000 ft
Amplitude in dB
Distance from the Antenna in nmi

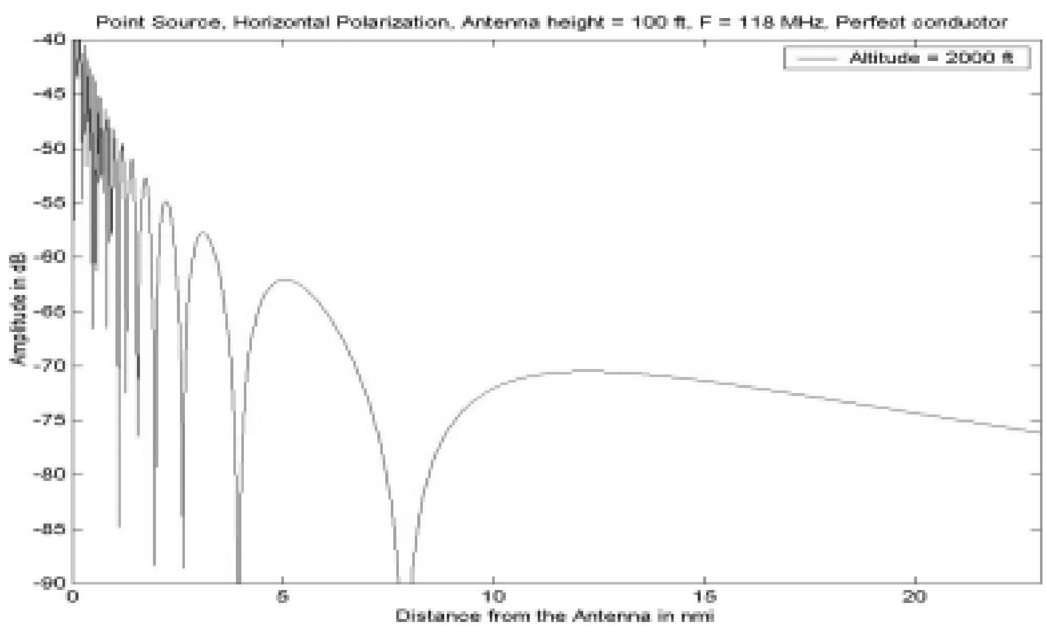

Point Source, Horizontal Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 6000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

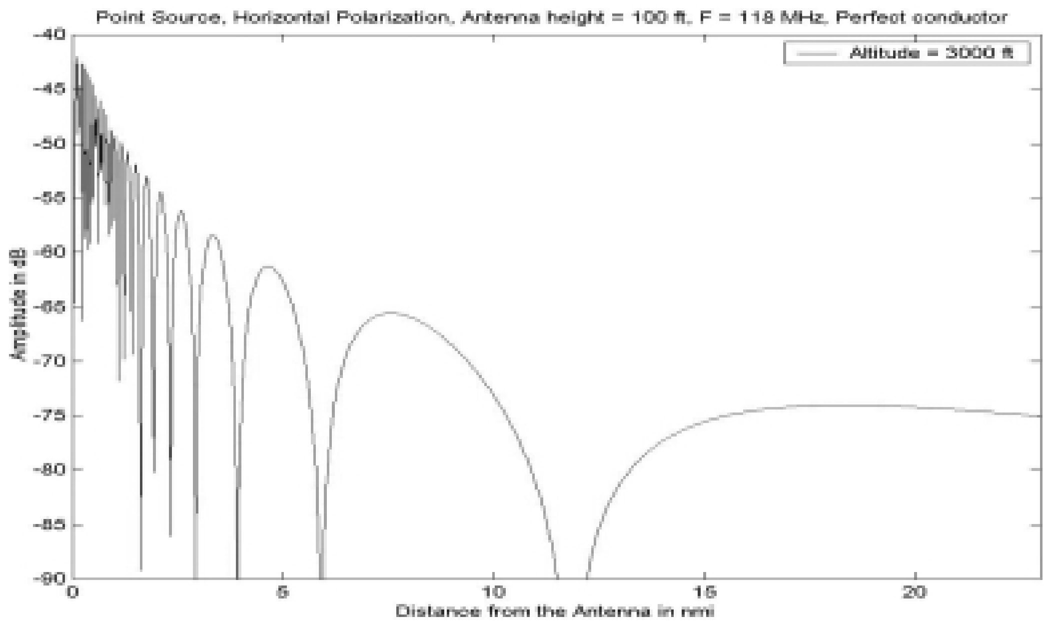

Point Source, Horizontal Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 7000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20


Point Source, Horizontal Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 8000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

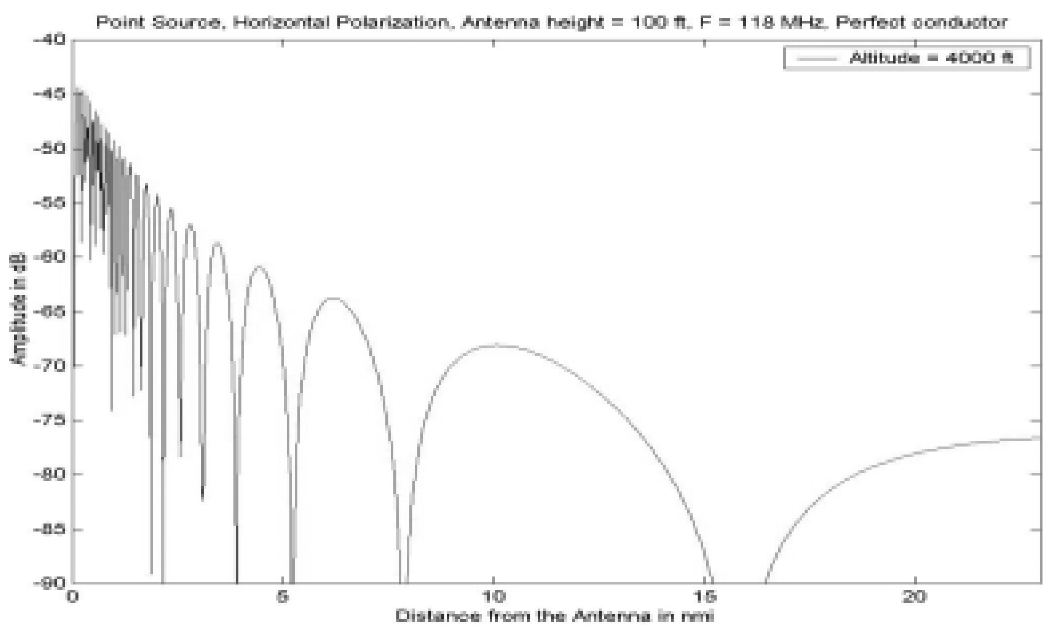

Point Source, Horizontal Polarization, Antenna height = 50 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 9000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20


Point Source, Horizontal Polarization, Antenna height = 60 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 10,000 ft
Amplitude in dB
Distance from the Antenna in nmi

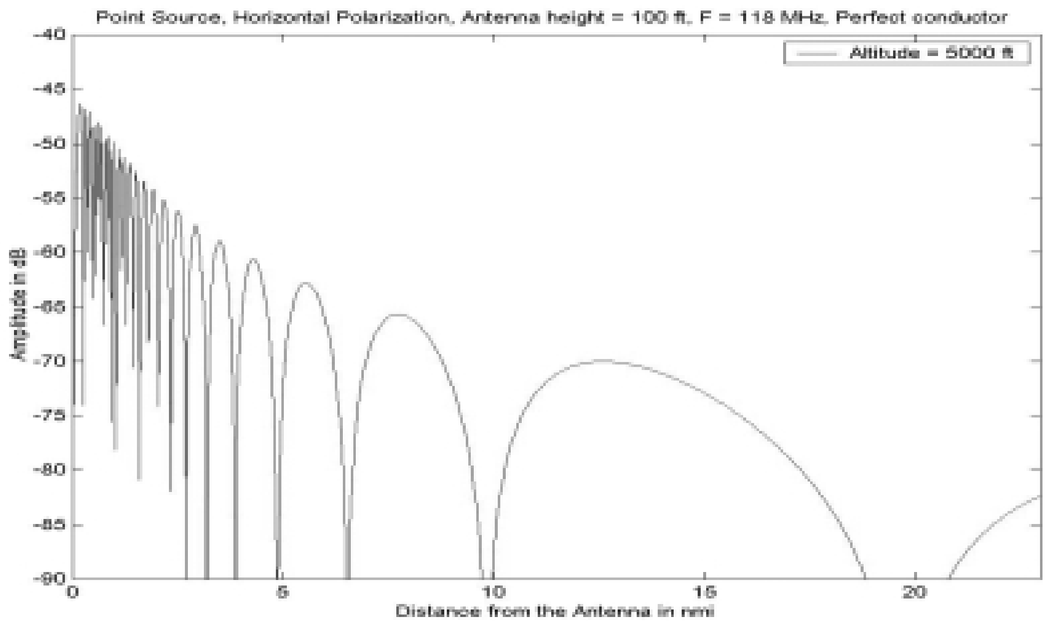

Point Source, Horizontal Polarization, Antenna height = 100 ft, F = 118 MHz, Perfect conductor
Altitude = 2000 ft
Amplitude in dB
Distance from the Antenna in nmi

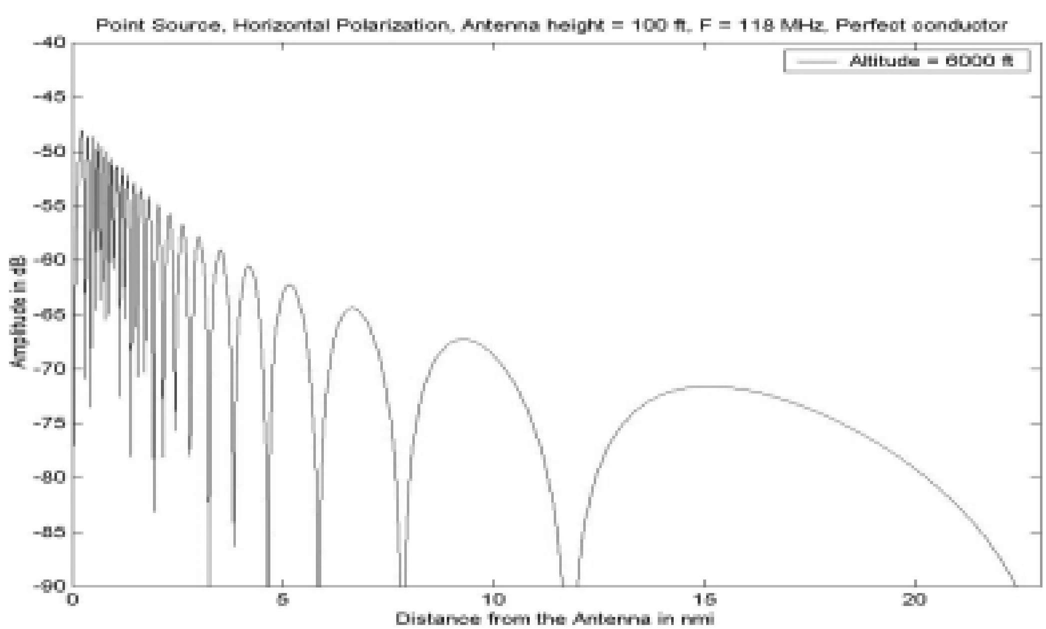


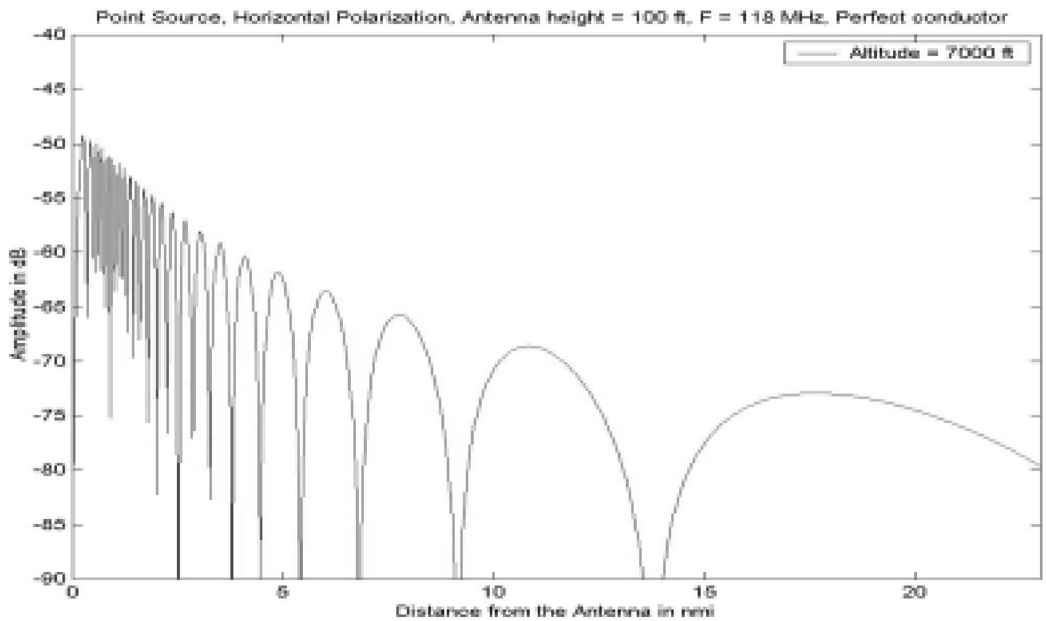
Point Source, Horizontal Polarization, Antenna height = 100 ft, F = 118 MHz, Perfect conductor
Altitude = 3000 ft
Amplitude in dB
Distance from the Antenna in nmi

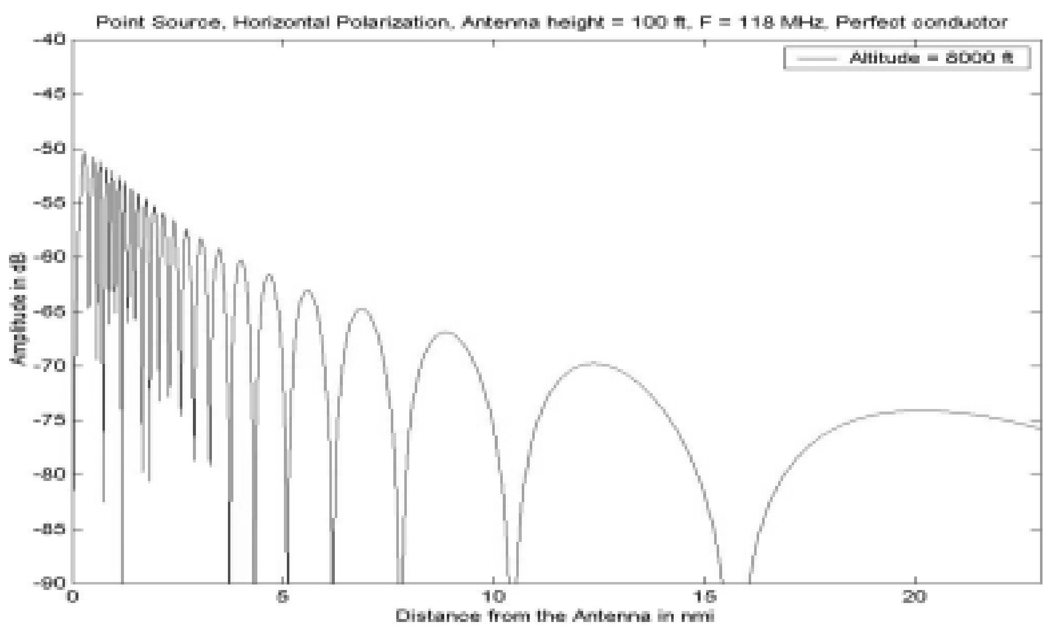


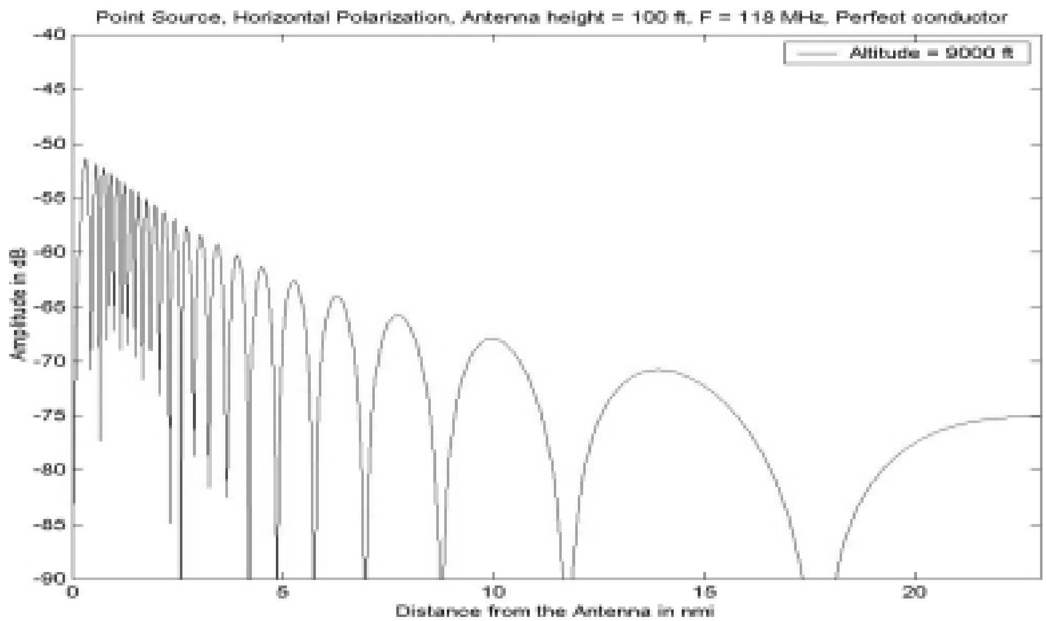
Point Source, Horizontal Polarization, Antenna height = 100 ft, F = 118 MHz, Perfect conductor
Altitude = 4000 ft
Amplitude in dB
Distance from the Antenna in nmi


Point Source, Horizontal Polarization, Antenna height = 100 ft, F = 118 MHz, Perfect conductor
Altitude = 5000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

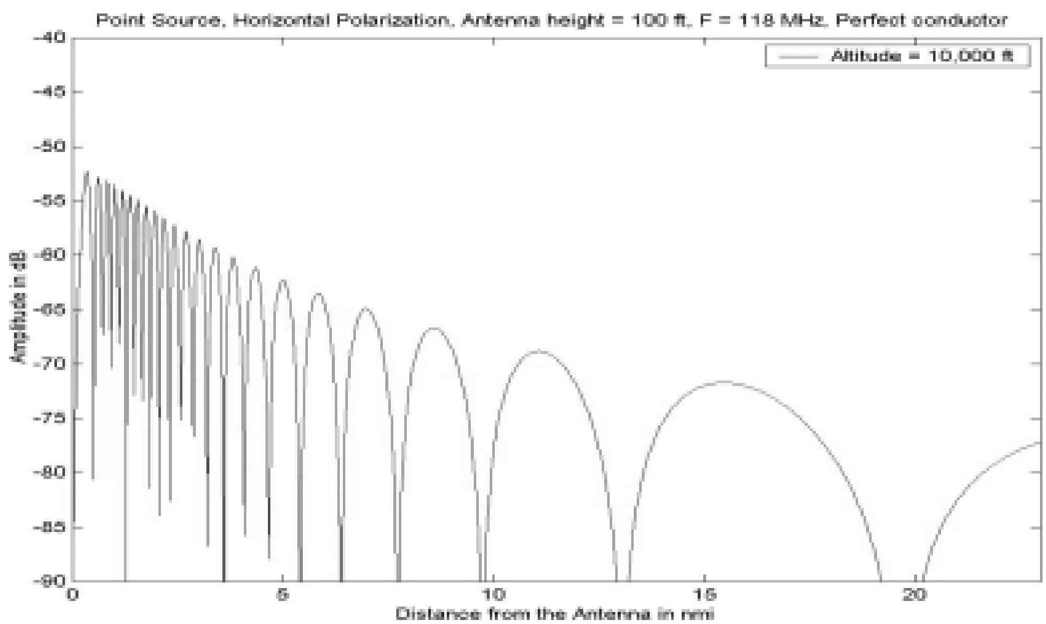

Point Source, Horizontal Polarization, Antenna height = 100 ft, F = 118 MHz, Perfect conductor
Altitude = 6000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20


Point Source, Horizontal Polarization, Antenna height = 100 ft, F = 118 MHz, Perfect conductor
Altitude = 7000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

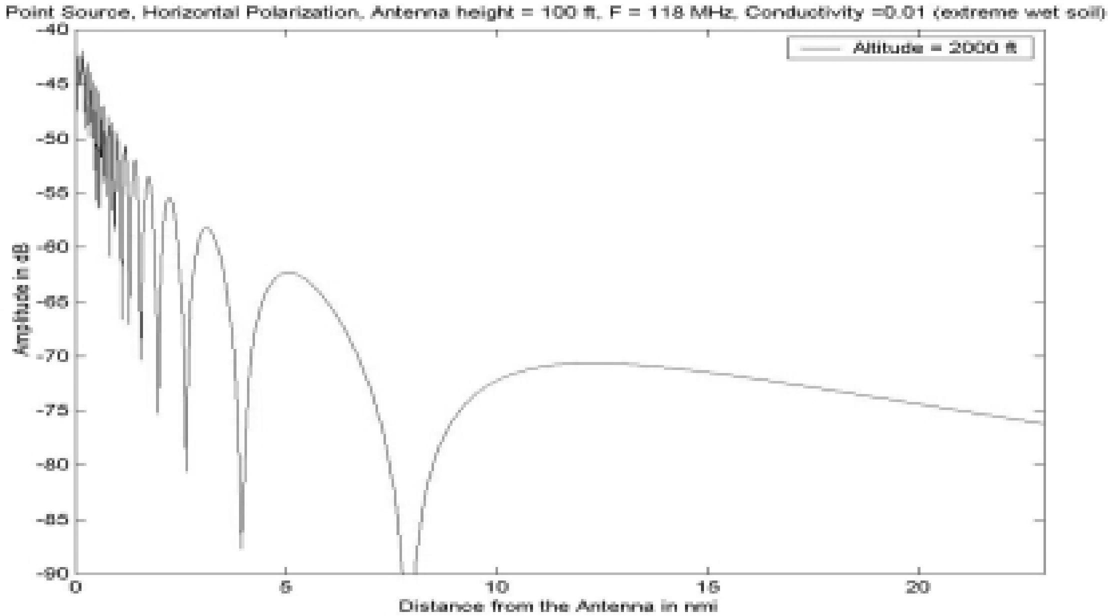

Point Source, Horizontal Polarization, Antenna height = 100 ft, F = 118 MHz, Perfect conductor
Altitude = 8000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

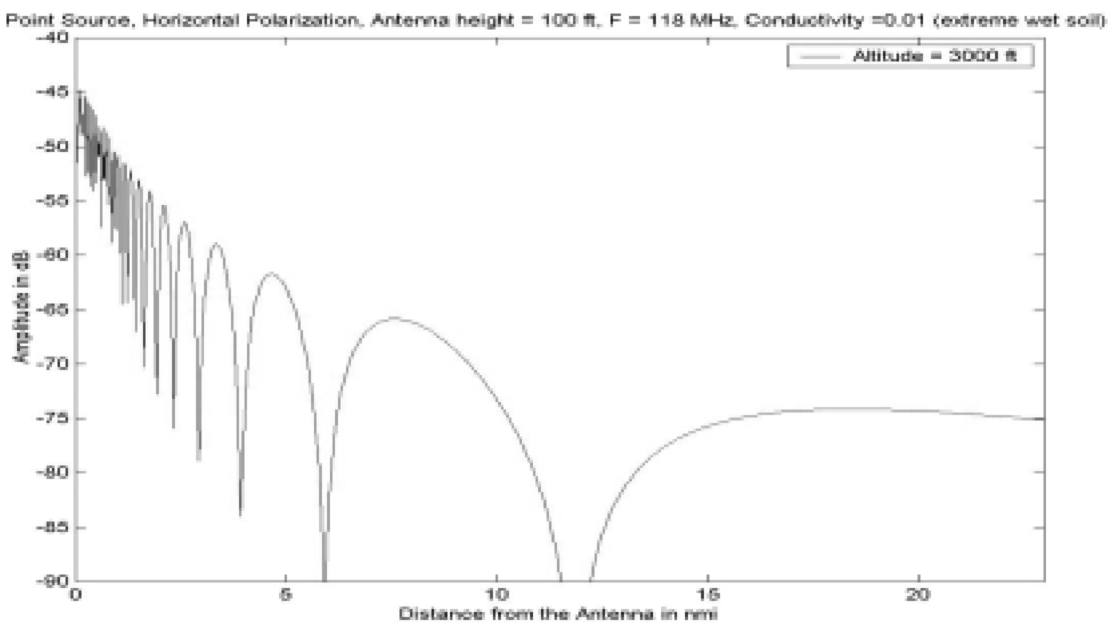


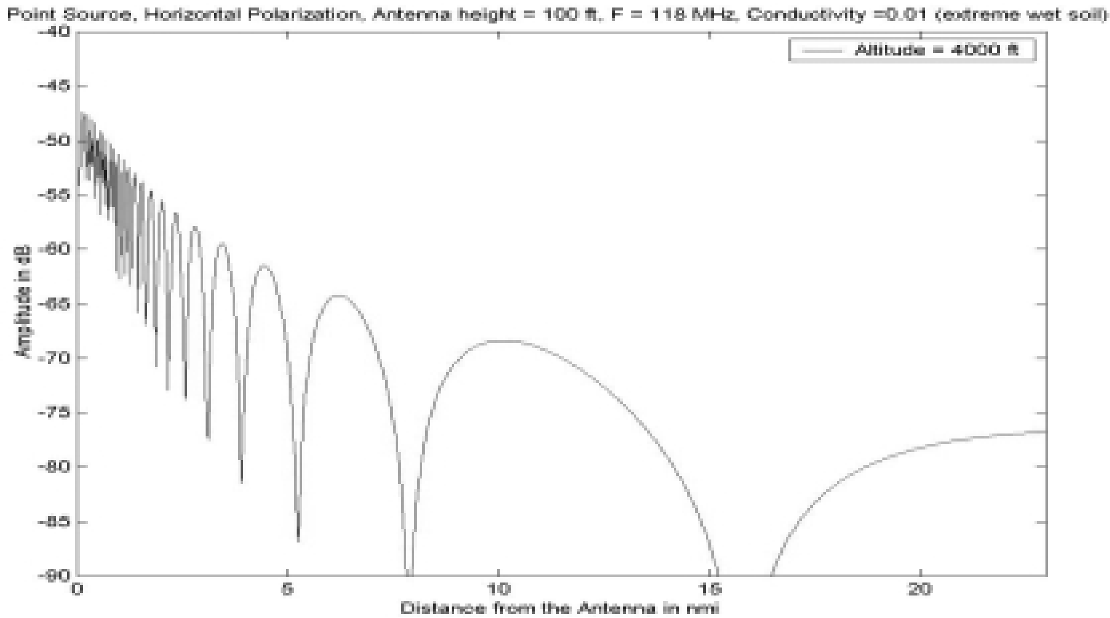
Point Source, Horizontal Polarization, Antenna height = 100 ft, F = 118 MHz, Perfect conductor
Altitude = 9000 ft
Amplitude in dB
Distance from the Antenna in nmi

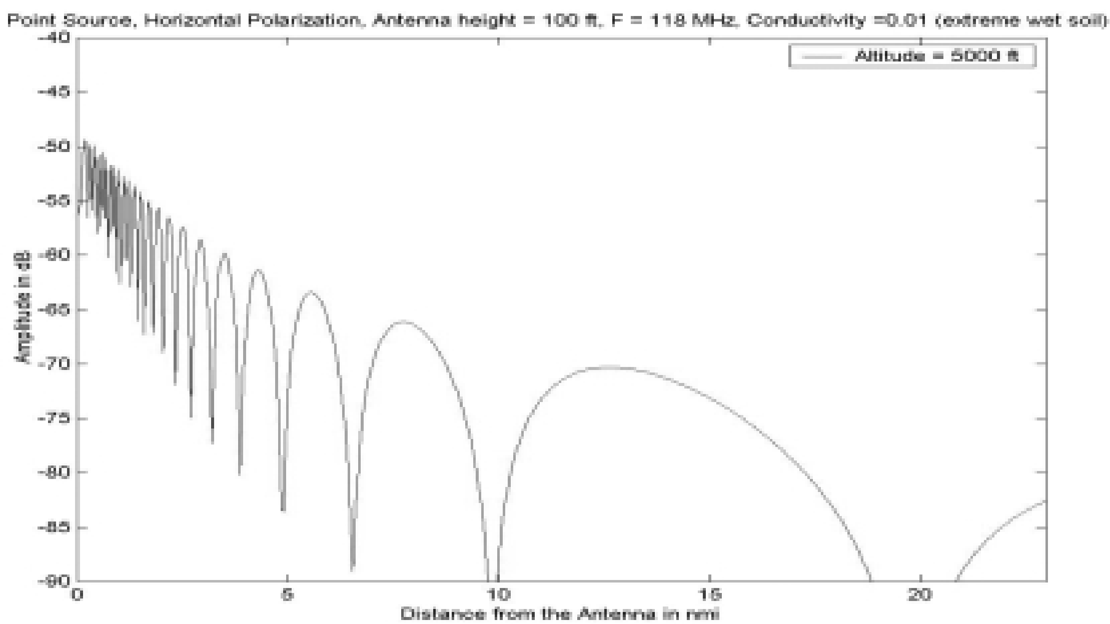


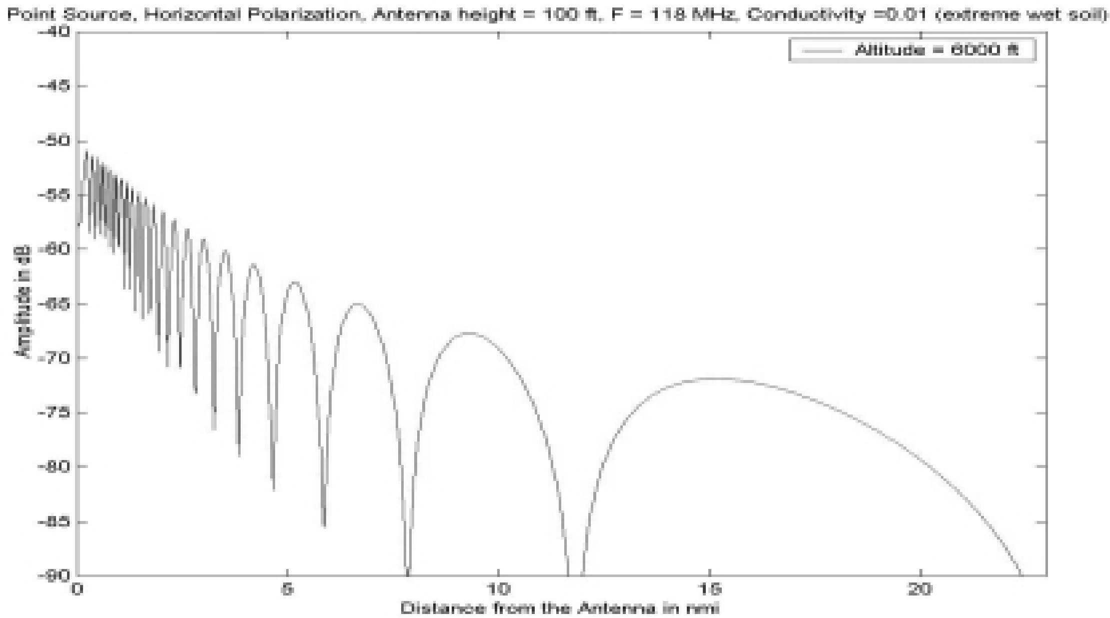
Point Source, Horizontal Polarization, Antenna height = 100 ft, F = 118 MHz, Perfect conductor
Altitude = 10,000 ft
Amplitude in dB
Distance from the Antenna in nmi


Point Source, Horizontal Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 2000 ft
Amplitude in dB
Distance from the Antenna in nmi

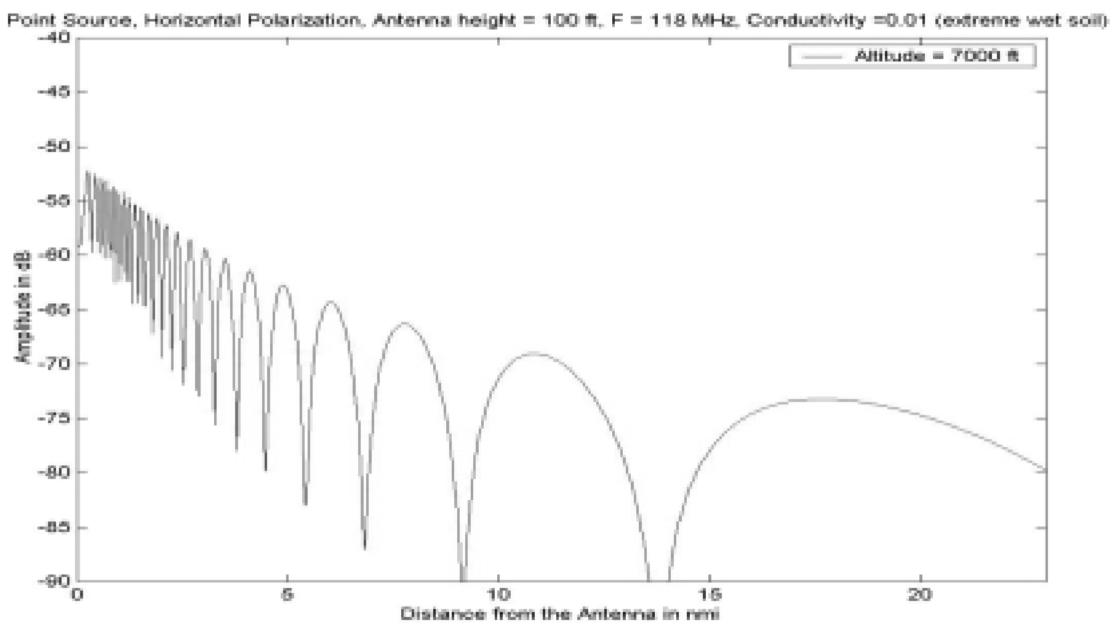

Point Source, Horizontal Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 3000 ft
Amplitude in dB
Distance from the Antenna in nmi


Point Source, Horizontal Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 4000 ft
Amplitude in dB
Distance from the Antenna in nmi

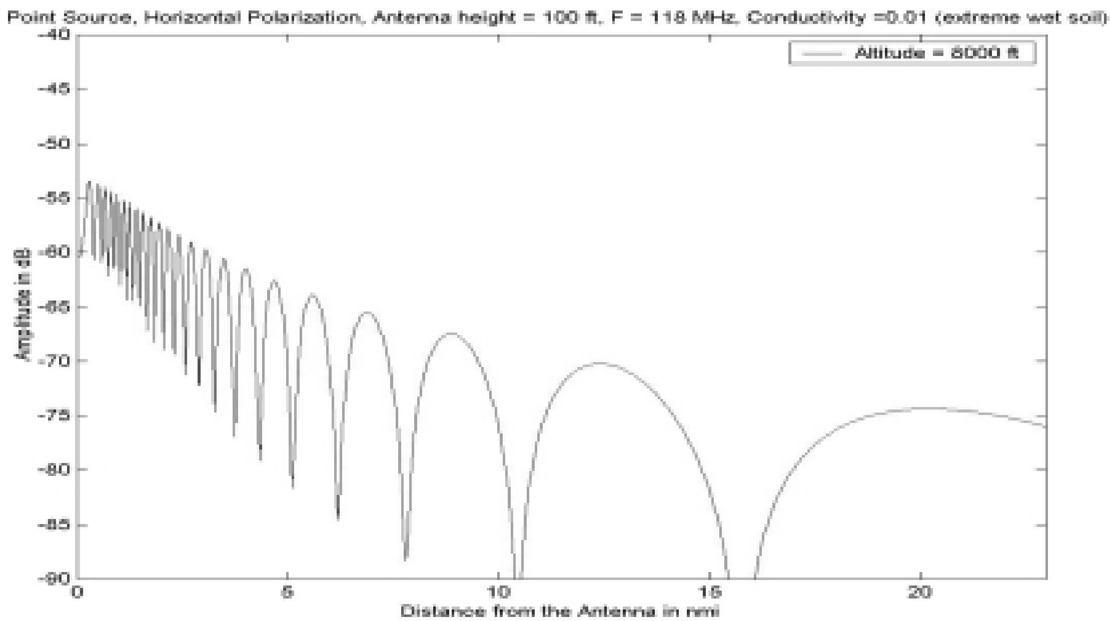

Point Source, Horizontal Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 5000 ft
Amplitude in dB
Distance from the Antenna in nmi

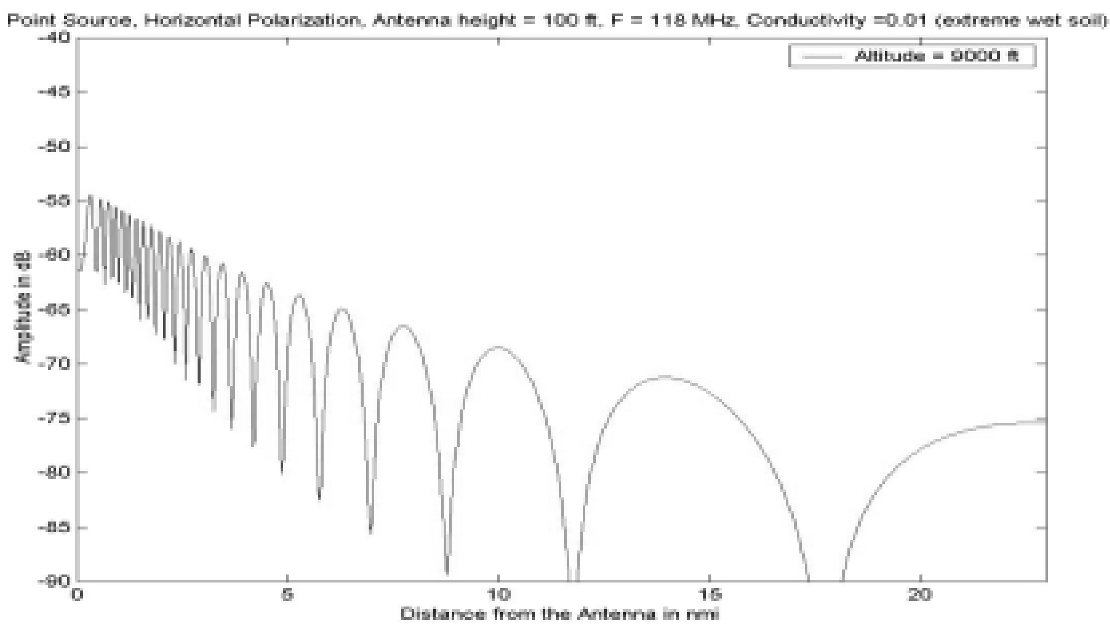


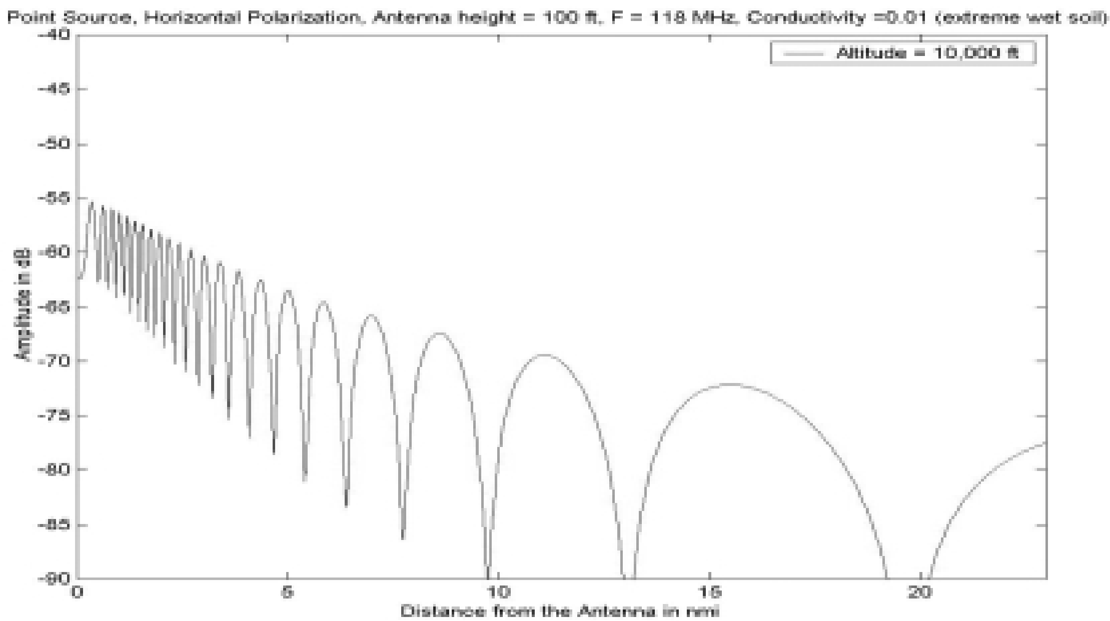
Point Source, Horizontal Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 6000 ft
Amplitude in dB
Distance from the Antenna in nmi

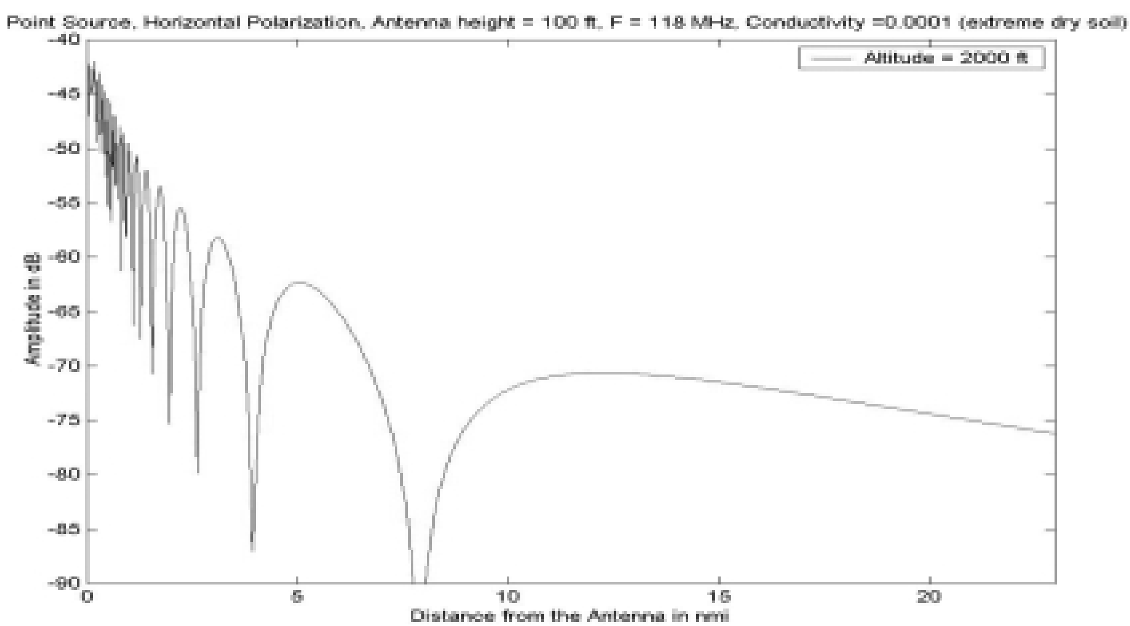


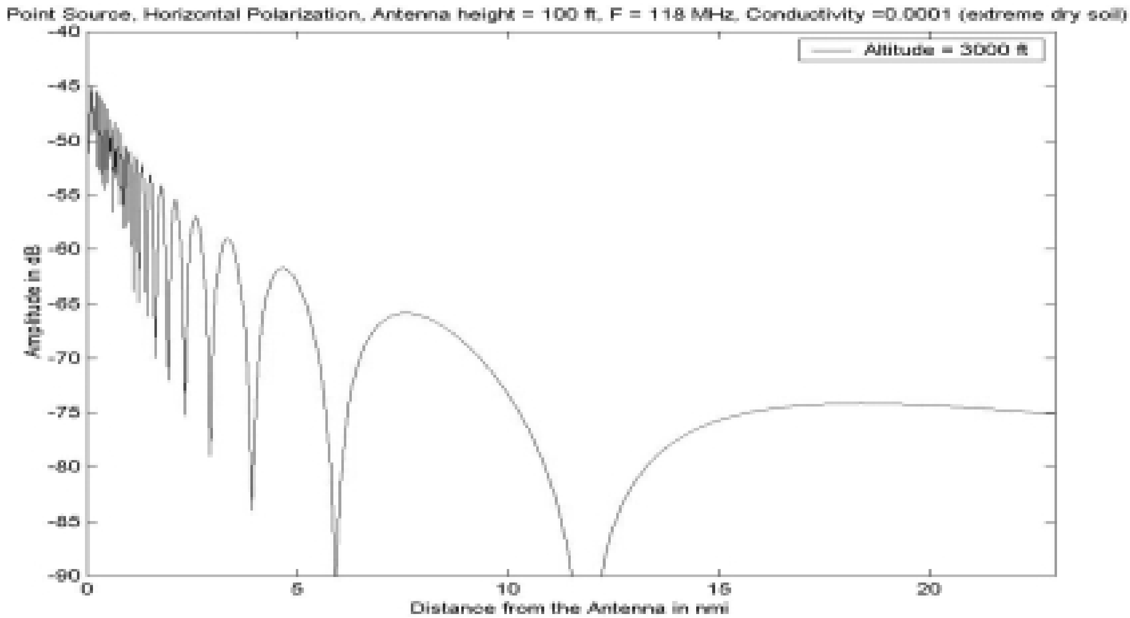
Point Source, Horizontal Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 7000 ft
Amplitude in dB
Distance from the Antenna in nmi

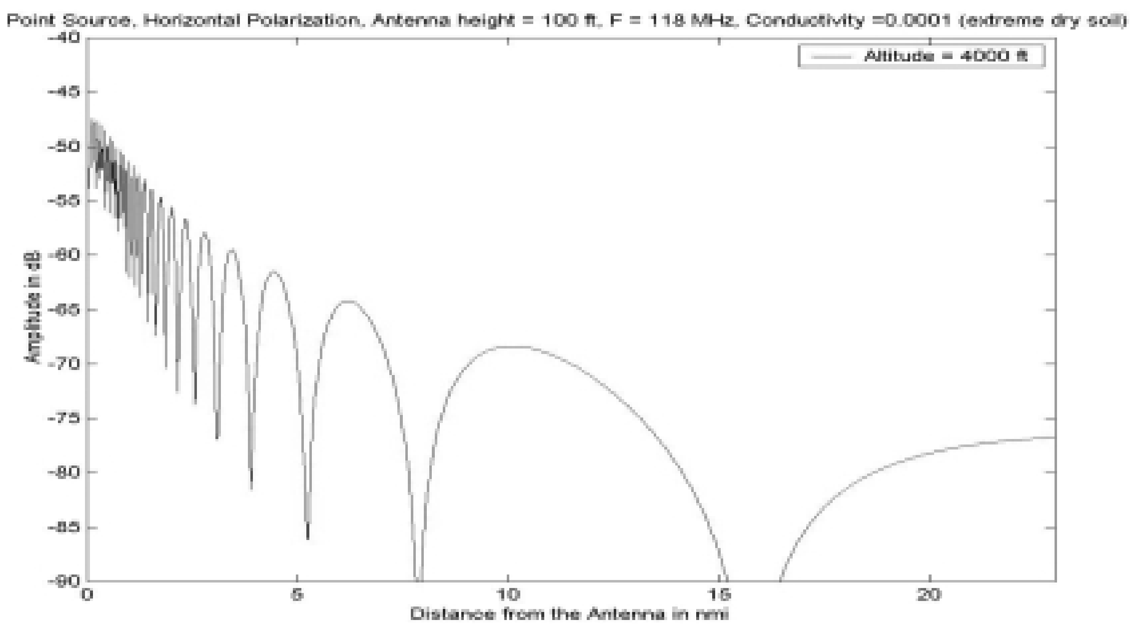

Point Source, Horizontal Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 8000 ft
Amplitude in dB
Distance from the Antenna in nmi

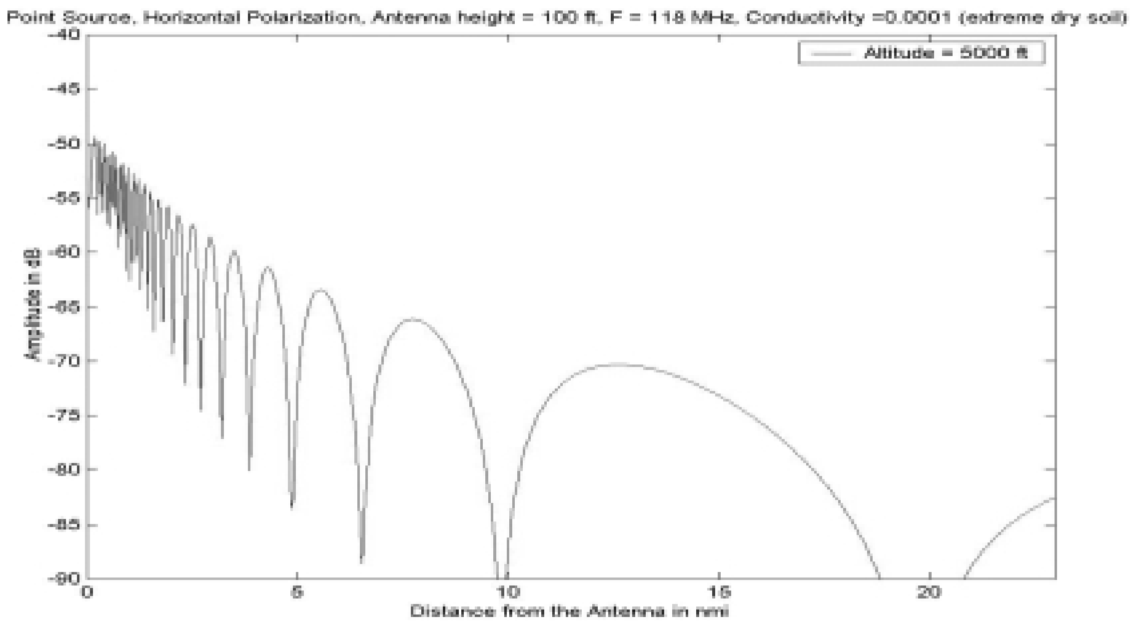

Point Source, Horizontal Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 9000 ft
Amplitude in dB
Distance from the Antenna in nmi

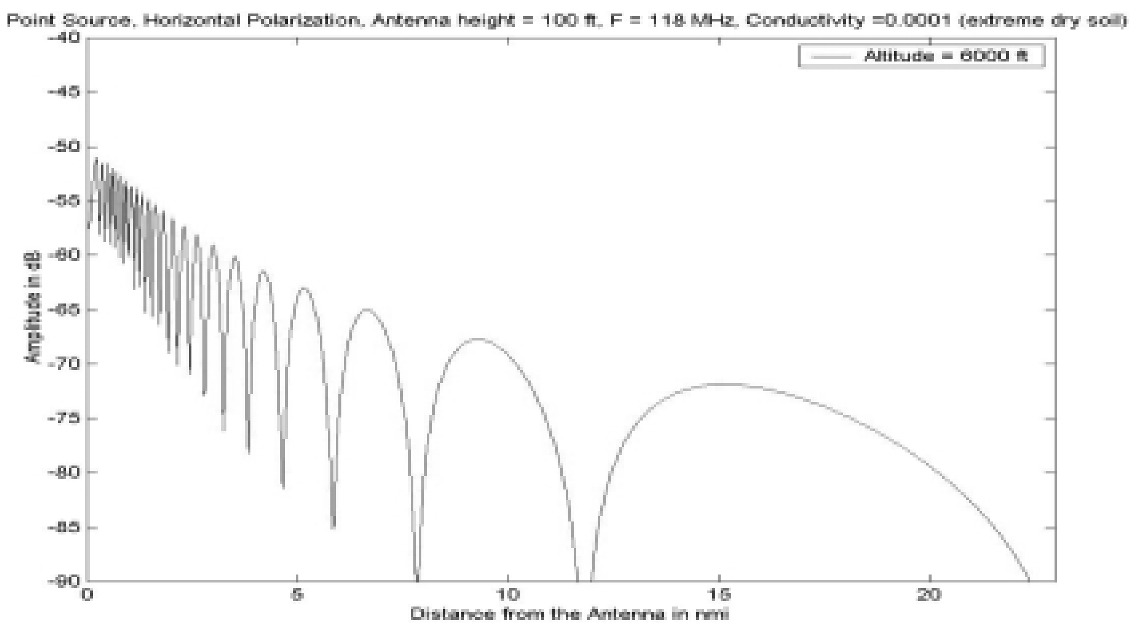

Point Source, Horizontal Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.01 (extreme wet soil)
Altitude = 10,000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

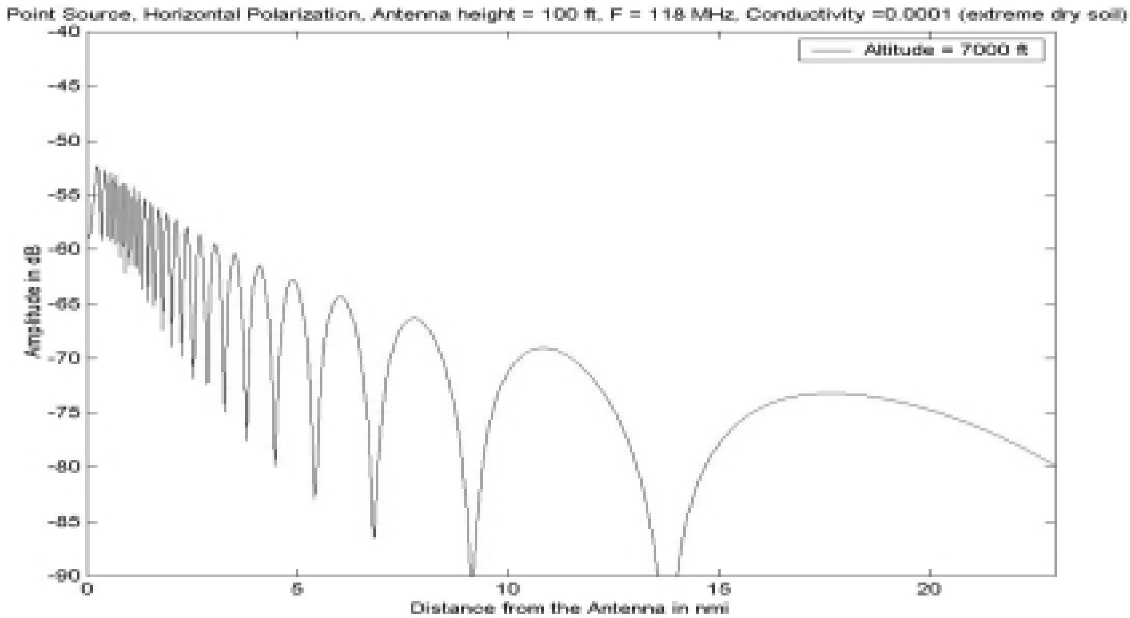

Point Source, Horizontal Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 2000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

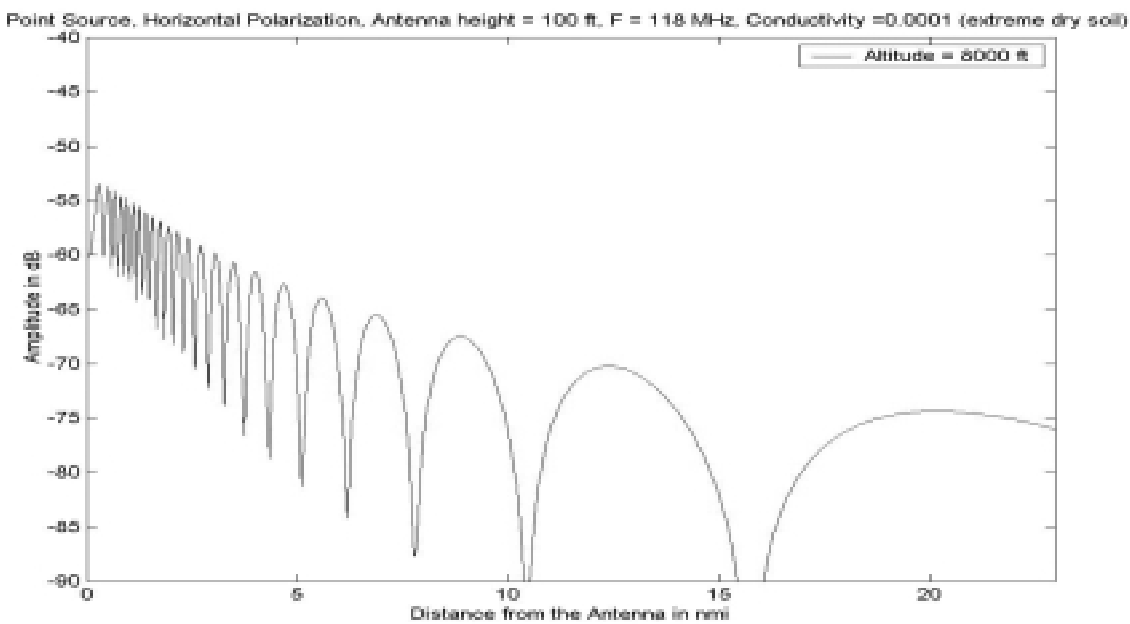

Point Source, Horizontal Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 3000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

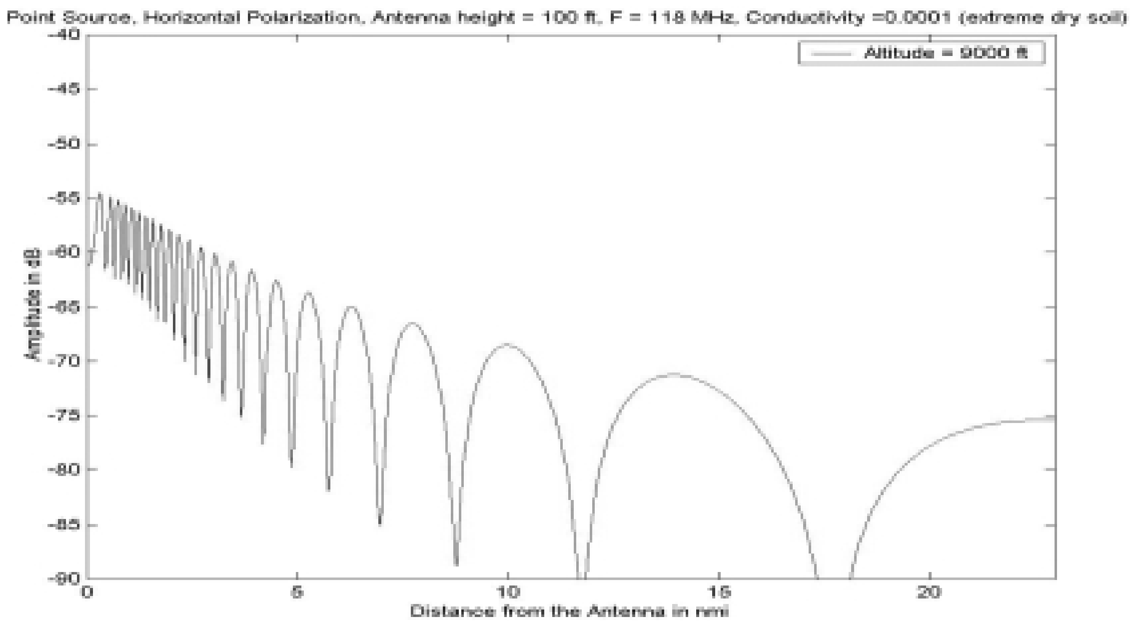

Point Source, Horizontal Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 4000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20

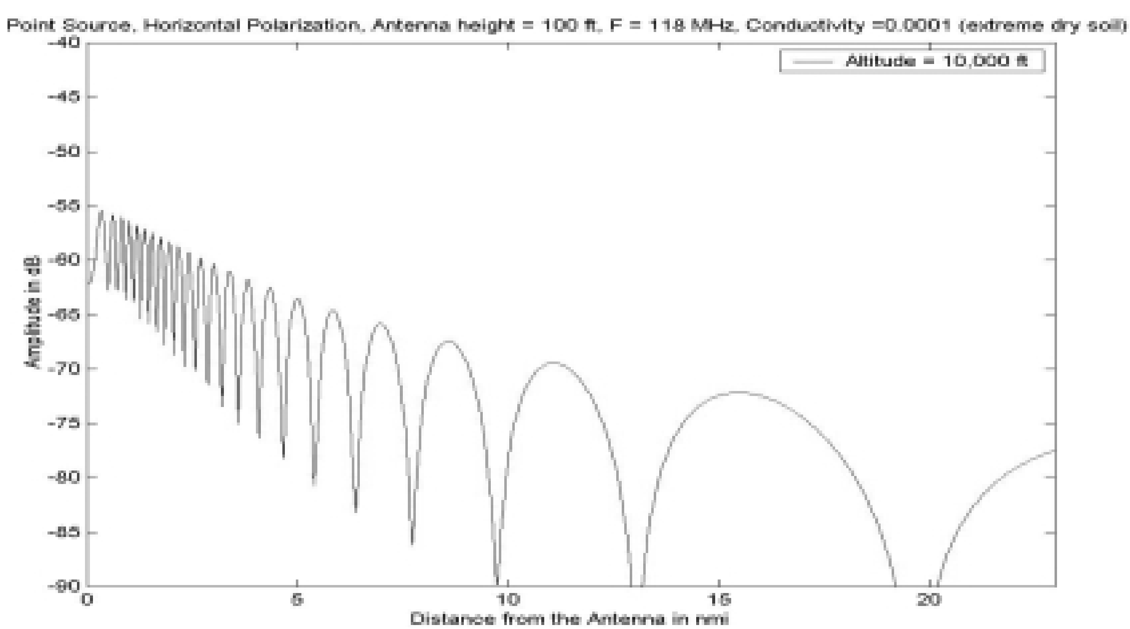

Point Source, Horizontal Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 5000 ft
Amplitude in dB
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20
Distance from the Antenna in nmi


Point Source, Horizontal Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 6000 ft
Amplitude in dB
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20
Distance from the Antenna in nmi


Point Source, Horizontal Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 7000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20


Point Source, Horizontal Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 8000 ft
Amplitude in dB
Distance from the Antenna in nmi
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0
5
10
15
20


Point Source, Horizontal Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 9000 ft
Amplitude in dB
Distance from the Antenna in nmi


Point Source, Horizontal Polarization, Antenna height = 100 ft, F = 118 MHz, Conductivity =0.0001 (extreme dry soil)
Altitude = 10,000 ft
Amplitude in dB
Distance from the Antenna in nmi